

GEORGIA INSTITUTE OF TECHNOLOGY



1980-81 General Catalog

Office of Publications
Georgia Institute of Technology

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About this Catalog

The statements set forth in this catalog are for informational purposes only and should not be construed as the basis of a contract between a student and this institution.

While the provisions of this catalog will ordinarily be applied as stated, Georgia Tech reserves the right to change any provision listed in this catalog, including but not limited to academic requirements for graduation, without actual notice to individual students. Every effort will be made to keep students advised of any such changes. Information on changes will be available in the offices of the registrar, the dean of students and the major schools and colleges. It is especially important that each student note that it is his or her responsibility to be aware of current graduation requirements for a particular degree program.

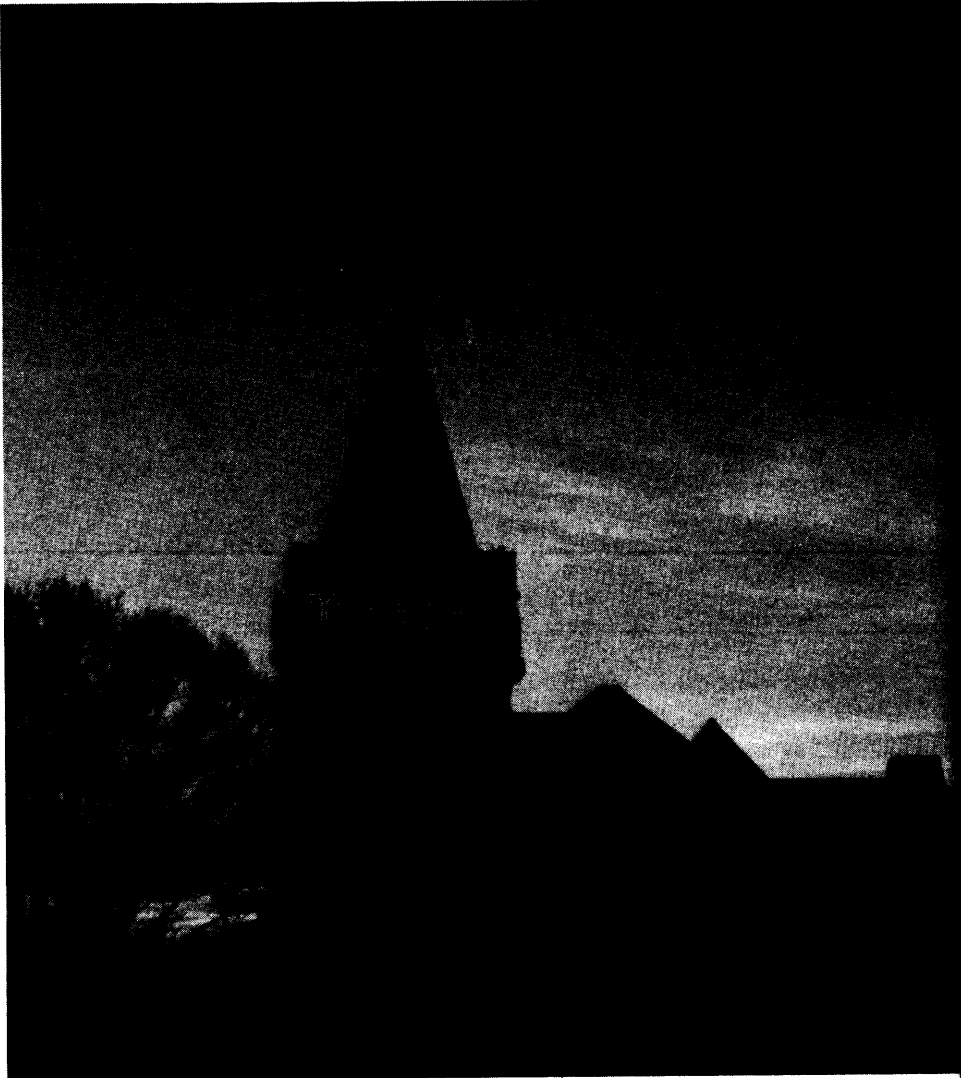
This institution is in compliance with Title VI of the Civil Rights Act of 1964 and does not discriminate on the basis of race, creed, color or national origin, and is also in compliance with the provisions of Title IX of the Educational Amendments of 1972 which prohibit discrimination on the basis of sex.

The cost of the 1980-81 *General Catalog* is \$37,000 for a total press run of 35,000 copies.

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Fred Gerlich, Dana Dobbs and Georgia Tech Student Publications

GENERAL INFORMATION



The Georgia Institute of Technology, founded in 1885, is a co-educational institution of higher learning located in Atlanta, Georgia.

In 1888 the school opened its doors to the first class of future mechanical engineers. At that time the campus consisted of five acres of land and a physical plant of two buildings. One of these original buildings is still in use daily as part of today's 28-building physical plant which sprawls over more than 300 acres of land.

Tech's enrollment has paralleled the growth of the physical plant. The original class numbered only 129 students, all but one from Georgia. This year over 11,000 students from every state and from over 78 countries are expected to pursue undergraduate or graduate degrees in the 20 engineering, architectural, scientific and management schools and colleges that make up Georgia Tech.

Nationally prominent in education and research, Georgia Tech is also famous for its colorful traditions—the Ramblin' Wreck parade and the school song of the same name, football and hard-working students who approach play with zest and ingenuity. Georgia Tech alumni support, from graduates scattered throughout the world, is consistently among the strongest in the nation. Tech students who take the Scholastic Aptitude Test score better than 250 points higher than the national average. Georgia Tech has the largest number of National Merit Scholars per capita of any publicly supported institution in the United States. And Tech ranks number one nationally in National Achievement Scholars; the equivalent to the honor of National Merit

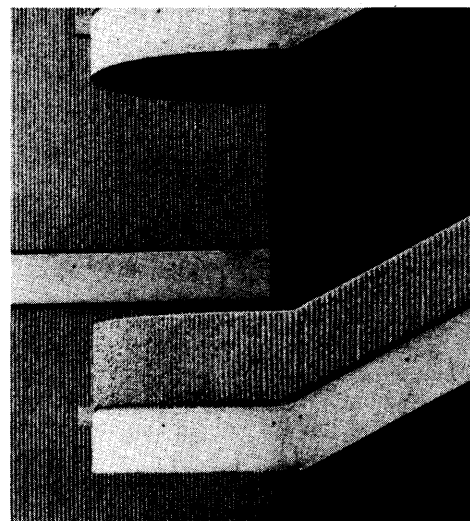
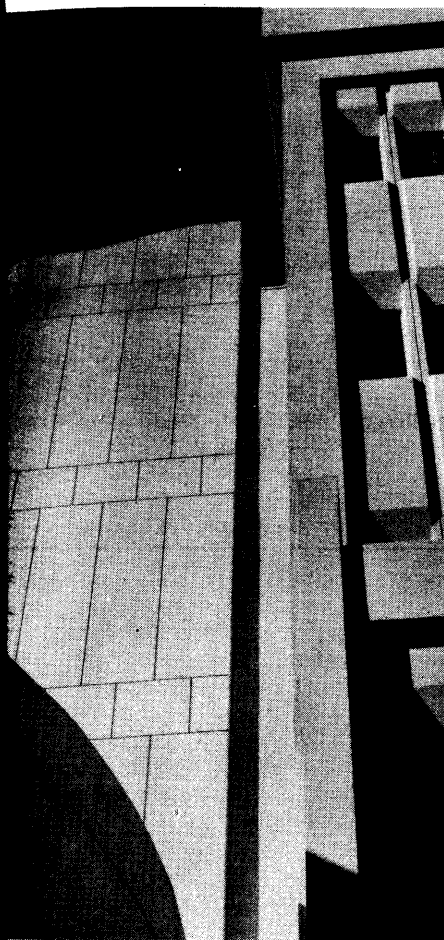
Scholars but composed solely of black students.

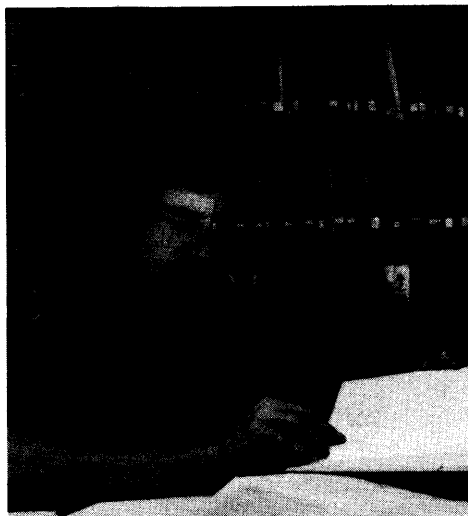
The definitive goal of the Institute is to provide quality education, service and research. Georgia Tech's extensive research program, with expenditures of over \$40 million annually, includes dynamically diverse and valuable projects.

The following are samples of studies ongoing at Tech. The client-oriented Engineering Experiment Station is currently involved in energy conservation and complex defense systems research. Medical isotopes are being manufactured by the Nuclear Research Center while the Environmental Resources Center is surveying levels of radiation in drinking water.

The Health Systems Research Center's Emergency Medical Care project is targeted at rural areas where no doctor or ambulance service is immediately available. And, the Bioengineering Center is progressing in its study of the effects of radio frequencies on heart pacemakers.

Quality is the key word at Georgia Tech. Quality Education, Service and Research.





ACADEMIC OFFERINGS

Through the Colleges of Engineering, Sciences and Liberal Studies, Management and Architecture, Georgia Tech offers programs of study leading to 27 undergraduate and 28 graduate degrees. General information about these programs is contained in the "Information for Undergraduate Students" and the "Information for Graduate Students" sections of this book. More specific information can be found in the "Curricula and Degrees" section.

ACCREDITATION

The Georgia Institute of Technology is an accredited member of the Southern Association of Colleges and Schools. Accreditation has been given by the Engineers' Council for Professional Development, the national engineering accrediting agency, the four-year engineering curricula leading to bachelor's degrees in the following fields: aerospace engineering, ceramic engineering, chemical engineering, civil engineering, electrical engineering, engineering science and mechanics, industrial engineering, mechanical engineering, nuclear engineering and textile engineering as well as to the graduate programs leading to master's degrees in the following fields: aerospace engineering, ceramic engineering, civil engineering, electrical engineering, industrial engineering, mechanical engineering, metallurgy, nuclear engineering, sanitary engineering and textile engineering. The curriculum leading to the degree Master of Architecture is accredited by the National Architecture Accrediting Board. The curriculum leading to the bachelor's degree in chemistry is accredited by the American Chemical Society. The College of Management is accredited by the American Assembly of Collegiate Schools of Business.

No accrediting agency has yet been established in the field of health systems, but the School of Health Systems has been admitted to associate institutional membership in the Association of University Programs in Health Administration for future accreditation review.

SPECIAL SUPPORT FACILITIES

Library

The Price Gilbert Memorial Library's scientific, engineering, architectural and management collection includes 950,000 volumes, 1,250,000 microtexts and 20,000 other bibliographic units.

The library has a collection of over four million patents, the largest in the Southeast. The library acquires research reports from the National Technical Information Service, the U.S. Department of Energy and the National Aeronautics and Space Administration. It is a depository for publications issued by the U.S. Government Printing Office and for maps issued by the U.S. Defense Mapping Agency, Topographic and Aerospace Centers, U.S. Geological Survey and the U.S. National Ocean Survey. The government documents collection contains 300,000 publications and 100,000 maps.

Over 12,000 serials, including 6,500 periodicals, are currently received, approximately 75 percent of them in scientific and technical fields. Especially strong is the collection of abstracts, indices and bibliographies for science and engineering.

The catalog record of the library collection has been converted to Computer Output Microfilm (COM). The COM catalog is located on each floor of the library in selected dormitory areas, in the Student Center and in each academic department. The Georgia Tech library is associated with

eight other libraries in the Atlanta area and in Athens, Georgia and offers a union catalog of the holdings of all member libraries.

Computing Facilities

The Office of Computing Services provides a wide range of computing services for education, research and administration. Since 1955 this centralized service facility has operated a variety of systems. In 1975 a Control Data Corporation CYBER 70 Model 74-28/CDC 6400 replaced UNIVAC 1108 and IBM 360/30 computing systems on the campus. The hardware configuration, the NOS operating system, a broad variety of programming languages, applications programs and library subroutines all combine to provide an impressive amount of computer power to both time-sharing, remote batch and on-site batch users. Data preparation equipment, time-sharing terminals, CALCOMP and Versatec plotters and an optical scanner are also available. Many schools, departments and administrative offices have interactive and remote batch terminals used to access the central facility in addition to their own minicomputers.

Engineering Experiment Station

The Engineering Experiment Station (EES) of the Georgia Institute of Technology is an applied research organization that performs investigations in engineering, science, computer technology and economic development for a diverse group of sponsors, including federal, state and local governmental agencies, industrial firms and foreign countries.

EES is chartered by the Georgia legislature as a non-profit, client-oriented organization. Its purpose is to serve the community, state and nation. EES conducts scientific, engineering and industrial research; encourages the development of natural resources in Georgia; aids industrial and economic development; and participates in national programs of science, technology and preparedness.

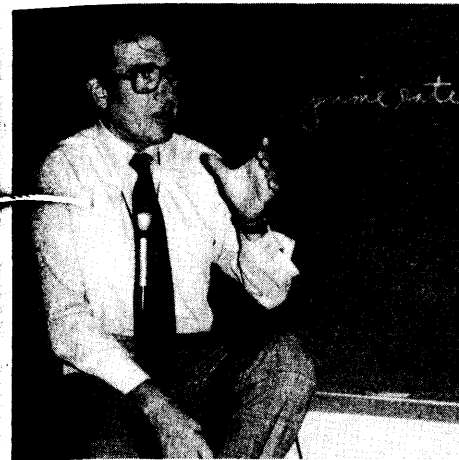
Activities of the Engineering Experiment Station are housed in a number of major buildings on the Georgia Tech campus, in off-campus leased space and in eight field offices located throughout the state in Albany, Augusta, Carrollton, Douglas, Gainesville, Macon, Rome and Savannah.

The EES staff represents almost all of the recognized fields of science and technology, with more than 500 professionals in the full-time staff of 650 persons. An additional 350-400 faculty, students and consultants participate on a part-time basis in the research programs.

The Engineering Experiment Station's activities are coordinated with research conducted by the academic colleges through the Vice-president for Research.



Additional information can be obtained from the Office of the Director, Engineering Experiment Station, Main Lobby, Hinman Building. 894-3411.



Continuing Education

This department annually conducts many educational programs designed to help professionals in engineering, science, architecture, and business keep pace with their fields, advance in their professions or retrain for a related field. Special technical and management short courses, as well as conferences and institutes, train key personnel in those areas by providing information and instruction concerning new developments and best methods of utilization. The department cooperates closely with industry, trade associations and professional organizations in planning and presenting these special educational programs. Through the recently acquired instructional television facilities of the Georgia Tech Media-based Instruction Center, courses which are in sufficient demand can be delivered in the Metro-Atlanta area via microwave transmission and by videotape to other locations.

Industrial Education

The program of this department is a joint effort of the Georgia Institute of Technology and the State Department of Education. Its primary purpose is to provide, upon request from industry, intensive training of front-line managers and production personnel, as well as industry training personnel, to meet specific industry needs. Under appropriate circumstances, special courses to meet unique industrial needs can be developed upon request. This training, and related conferences and seminars, can be offered, either in-plant, through a convenient nearby facility, or via the instructional television facilities of the Georgia Tech Media-based Instruction Center.



Health Systems Research Center

The Health Systems Research Center (HSRC) was established in 1969 by the Regents of the University System of Georgia as an interdisciplinary and interinstitutional program of health systems research, community outreach and continuing education, building upon a health related academic program activated at Georgia Tech in 1958.

The general aim of HSRC is to develop, apply and disseminate new knowledge and techniques in the analysis, planning, design, implementation, demonstration and evaluation of improved operational and managerial systems for the delivery of health care services to the public, utilizing systems science and management engineering. Emphasis is upon systematic planning, engineering design and scientific management in respect to health care facilities, manpower and methods.

Organizationally, HSRC is the community outreach arm of the School of Health Systems within the College of Engineering. The center is affiliated with the Division of Systems and Computer Services of the Medical College of Georgia in Augusta. It maintains active collaboration with other academic institutions, hospitals and other health care organizations, health planning and governmental agencies and other groups throughout Georgia and other states and in several foreign countries.

Faculty and students of the various schools of Georgia Tech may participate in HSRC programs and utilize the center as a

focal point and mechanism for interdepartmental research programs or projects and for cooperative arrangements with the outside community.

Health systems courses and curricula leading to the Bachelor of Science in Health Systems and the Master of Science in Health Systems are administered by the School of Health Systems of the College of Engineering and are described in the sections "Curricula and Degrees" and "Courses of Instruction."

Nuclear Research Center

The Frank H. Neely Nuclear Research Center provides Georgia Tech with outstanding research facilities in the fields of nuclear science, engineering and bioengineering. In the center are a five megawatt heavy-water moderated research reactor with multiple irradiation facilities, a 100 kilocurie remotely operated hot cell, a 100 kilocurie cobalt 60 irradiation facility, radiochemistry laboratories, counting facilities, PDP data acquisition systems and a complete machine shop. The center is under the administrative responsibility of the School of Nuclear Engineering. It also houses the Center For Engineering in Cancer Therapy.

Oak Ridge Associated Universities

Georgia Tech is one of the sponsors of Oak Ridge Associated Universities (ORAU), a nonprofit education and research management corporation of 43 colleges and universities. ORAU conducts programs of research, education, information and human resource development for a variety of government and private organizations. It is particularly interested in the areas of energy, health and the environment.

Among ORAU's activities are competitive programs to bring undergraduates, graduate students and faculty members to work on research problems at the research facilities of the United States Department of Energy. Participants are selected by ORAU and the staffs of the facilities participating in the ORAU programs, which are Oak Ridge National Laboratory, the Oak Ridge Y-12 Plant, the Oak Ridge Gaseous Diffusion Plant, the Atmospheric Turbulence and Diffusion Laboratory in Oak Ridge, the Savannah River Laboratory and Savannah River Ecology Laboratory in Aiken, S.C., the Comparative Animal Research Laboratory in Oak Ridge, the Puerto Rico Nuclear Research Center and the Energy Research Centers at Bartlesville, Okla., Pittsburgh, Pa. and Morgantown, W. Va. The ORAU Institute for Energy Analysis, the Special Training Division, the Medical and Health Sciences Division and its other programs are also open to qualified students and faculty members.

Undergraduate Program

The ORAU Undergraduate Research Training Program offers juniors majoring in the sciences, engineering and mathematics an opportunity to spend ten weeks during the summer working in directed research programs at these sites.

Graduate Program

The ORAU Laboratory Graduate Participation Program enables a candidate for an advanced degree, upon completion of all requirements for work-in-residence except research, to work toward completion of his or her research problem and preparation of the thesis at one of the participating sites.

Stipends are available. The student stipends are at fixed rates that change from time to time. Dr. L. E. Weaver, director, School of Nuclear Engineering, is the Georgia Tech representative.

Skidaway Institute of Oceanography

Located on Skidaway Island near Savannah, the Skidaway Institute provides a complex of coastal- and marine-related educational and research opportunities. Members of the Tech faculty and their students can arrange to participate in ongoing research or initiate research consistent with the facility's purpose.

Interdisciplinary Programs

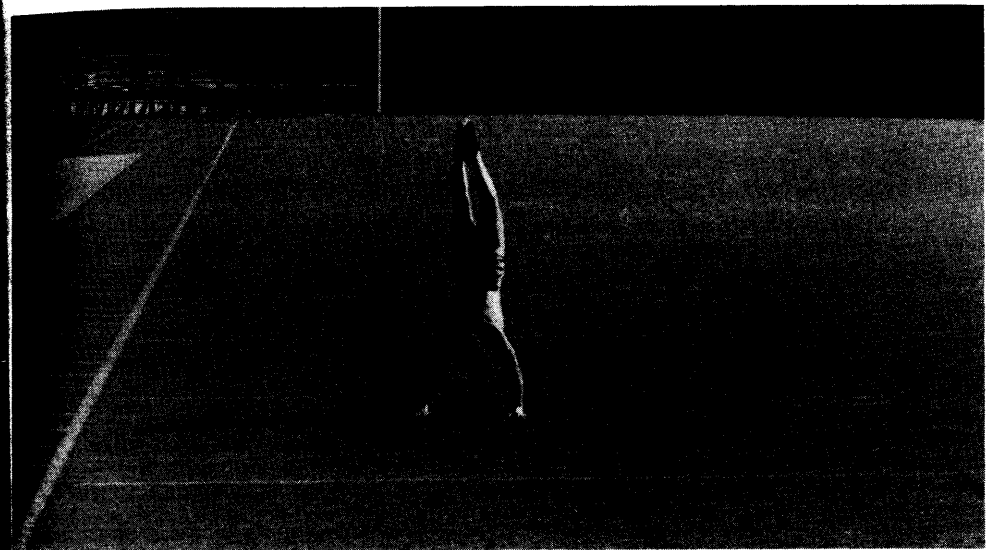
The Office of Interdisciplinary Programs, established in October 1973, is a focus for interdisciplinary study at Georgia Tech. There are currently three units, the Bioengineering Center, the Environmental Resources Center and the Center for Radiological Protection, within the Office of Interdisciplinary Programs. None of the centers offers designated degrees, but members of the faculty teach courses in other departments and schools of the Institute, assist in the development of interdisciplinary curricula, conduct various research projects, engage in public service programs and coordinate appropriate interdisciplinary activities.

The Bioengineering Center's emphasis is on the application of the knowledge, techniques and approaches of the physical sciences, engineering, social sciences and management to the problems of the biological sciences. In addition to developing interdisciplinary study and research opportunities for qualified students at Georgia Tech, the center conducts cooperative programs in bioengineering education and research with other units of the university system and with several private universities and foundations.

The Environmental Resources Center coordinates applications of Tech's expertise in science and technology to address problems of managing environmental resources. It organizes and administers water resources research projects throughout Georgia and disseminates their results.



The Center for Radiological Protection serves as a focus for research and training in radiological protection (health physics). Research is conducted and coordinated by its faculty and analytical support is provided through its Environmental Radiation Laboratory. These research programs are complementary to and supportive of Nuclear Engineering's undergraduate and graduate degree programs in health physics.



STUDENT LIFE

Coordinating and administering extracurricular student services and activities are the responsibilities of the dean of students and the dean's staff. Complete information concerning all student activities, organizations and general student information is contained in the *Student Handbook*, available to all students on campus.

Community Services

Georgia Tech applies its resources through community services to the needs of the community and provides outlets for creative individual response to social problems.

Counseling Center

Students with almost any difficulty may find assistance at the Counseling Center. Professional counselors assist in a completely confidential manner with academic, career and personal difficulties whenever requested. Additional services include career information, catalogs from other colleges, information for admission to law, business and graduate schools and a wide variety of interest, ability and personality tests and seminars.

Fraternities and Sororities

The many activities and programs of the 33 social fraternities and sororities on the Tech campus are coordinated and administered by the Fraternity Affairs and Women's Program Offices.

Housing Office

The Housing Office supervises 3,550 single spaces and 300 married student apartments. A residence hall program provides counselor services, programs and activities for the dormitory residents. For further information refer to the *Residence Hall Guidebook* available at the Housing Office.

Infirmary

The modern 70-bed infirmary is fully staffed with medical doctors, including a psychiatrist, registered nurses and technicians. All students are provided this service for a quarterly fee. Major medical insurance is optional at a nominal fee.

International Students

Students' services and programs help students from other countries adjust to Georgia Tech and to American customs and culture. Many of the 900 students from 78 foreign countries assist in providing programs to promote intracultural understanding and adjustment.

Orientation (FASET)

The student orientation program familiarizes the new undergraduate student with the activities and academic programs at Georgia Tech as well as the traditions, services and opportunities on campus.

Placement

The Georgia Institute of Technology operates a centralized placement operation serving all degree candidates for career employment. The principal services available to students and employers are campus interviews, a weekly bulletin listing position vacancies and communication information for more than 3,000 prospective employers. In addition, the Fred W. Ajax Placement Center staff conducts orientation and employment seminars to aid students in their employment search. Summer and part-time position openings are also made known to the students through the placement center. Formal campus interview periods are October and November and January through April.

Student Center

The staff of the Fred B. Wenn Student Center plans and coordinates programs and activities for students, faculty, alumni and their guests. The buzzing hub of the campus, the Center has post office, recreational, exhibit and hobby facilities available to serve a range of interests as diverse as Tech's student body.

Student Government

Tech's student government provides the means for self-government in all areas of the institution's student-related activities. Through the student council and the graduate senate the student body maintains responsible and respected participation in both academic and non-academic areas which affect the student.

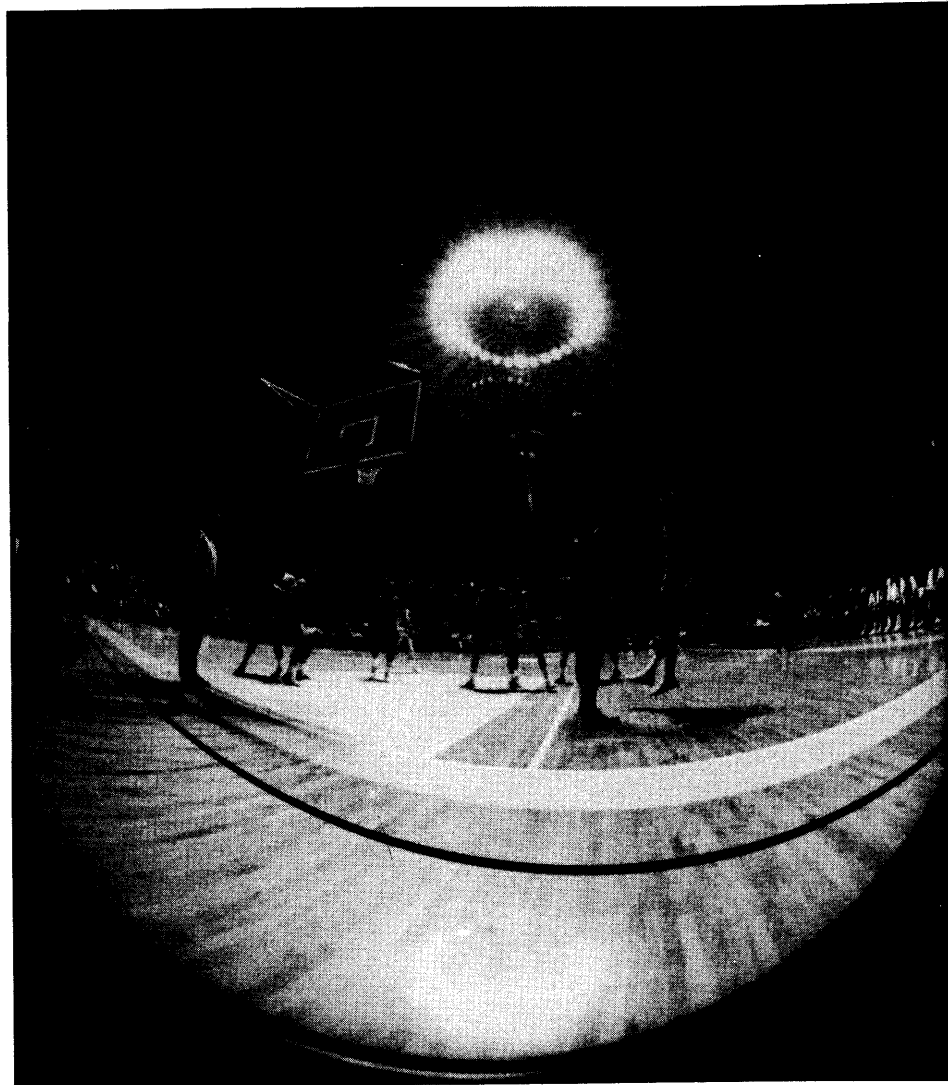


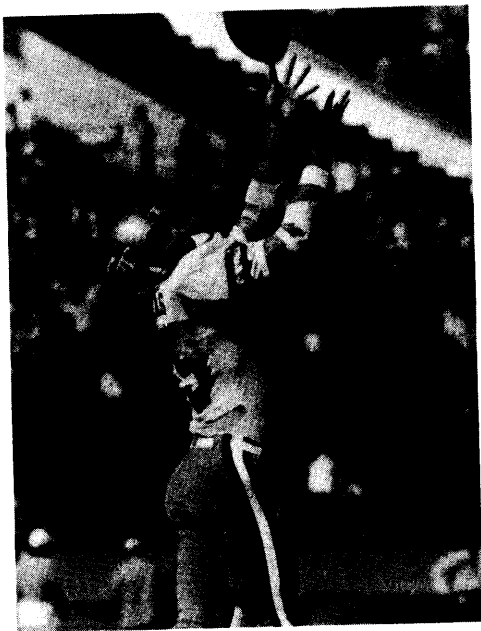
Student Publications and Radio

The student publications and radio communications boards oversee the budgeting and operation of the *Technique*, the official student newspaper, the *Blueprint*, the student yearbook and other publications in addition to the operation of the student FM radio station, *WREK*.

Women's Programs

Students' services and programs are directed toward involving female students in all phases of campus life and providing resources to fulfill the Institute's intention of accepting as many qualified female students as apply.





HEALTH INFORMATION

Health information record forms are mailed to students with the notice of their acceptance for enrollment. These forms are to be completed by the prospective student and mailed to the director of health in sufficient time to be received prior to the date of initial registration. After review of the report, the school physicians determine the assignments to physical training.

Any student who desires special consideration because of mental or physical disability should have his or her physician write an explanatory letter to the director of health giving full details of the disability and any desired limitations on physical activity. This letter is to be attached to the health information record. Any special examinations or reports needed to determine eligibility for enrollment or assignment are at the expense of the student, not the school. Any student who fails to submit the required immunization record prior to registration will have the necessary immunization ordered by the school at the expense of the student. Completed forms should be mailed to:

Director of Health
Student Health Service
Georgia Institute of Technology
Atlanta, Georgia 30332

ASSISTANCE FOR THE HANDICAPPED

Georgia Tech has a committee for handicapped assistance and planning. The committee is looking at the long-range requirements in order to be in compliance with the federal law and also to the mid-range plans.

The purpose of this notice is to publicize the fact that we do assist the handicapped today on a case by case basis.

Handicapped persons who may have problems with access to buildings and in parking should contact the director of campus safety at 894-4588 for resolution. If you know of any handicapped persons in need of assistance, please do not hesitate to notify either the equal opportunity/affirmative action officer, the dean of students or the director of campus safety.

For more information concerning the handicapped, contact the equal opportunity/affirmative action officer in the Carnegie Building at 894-5054.

ANNUAL NOTICE OF PRIVACY RIGHTS

This institution is covered by the Family Educational Rights and Privacy Act of 1974 (FERPA), which is designed to protect student rights with regard to educational records maintained by the institution. Under this Act, students have the following rights:

(1) the right to inspect and review educational records maintained by the institution that pertain to them; (2) the right to challenge the content of records on the ground that they are inaccurate, misleading or a violation of their privacy or other rights; and (3) the right to control disclosures from their educational records with certain exceptions.

A written policy detailing how Georgia Tech will comply with the provisions of the Act is printed in the *Student Handbook* and a copy can be obtained in the Office of the Dean of Students. The registrar has the institutional responsibility for interpreting (a) the Family Educational Rights and Privacy Act of 1974, as amended, (b) rules and regulations issued by the Department of Health, Education and Welfare to enforce this Act and (c) the written policy of the institution.

Students who believe the institution has violated the written policy and/or the provisions of the Family Educational Rights and Privacy Act should send a written complaint to the registrar, specifying the nature of the possible violation. The registrar shall investigate the complaint and initiate corrective action if it appears the institution is in violation. The registrar shall notify the complainant of the results of the review within a reasonable period of time, not to exceed 30 calendar days. Students also have the right to file complaints with the FERPA Office of the Department of Health, Education and Welfare, Washington, D.C. 20201 regarding alleged violations of the Act.

AFFILIATED ORGANIZATIONS

The Georgia Tech Athletic Association

This nonprofit corporation administers intercollegiate sports at Georgia Tech. The board of trustees consists of seven faculty members, three alumni and three students. The president of Tech is president of the board. The board aims to secure cooperation of the faculty and students in athletic affairs, to maintain a high standard of sportsmanship and to maintain facilities which make it possible for students to take part in athletic activities. Intercollegiate schedules are played in football, basketball, cross country, swimming, track, golf, tennis, baseball, gymnastics, wrestling, volleyball and softball.

The Georgia Tech Alumni Association

The Alumni Association is a nonprofit corporation dedicated to serving Georgia Tech. Some of its objectives are to maintain an up-to-date record of each alumnus, publish *Tech Topics* and the *Georgia Tech Alumni Magazine*, organize and service local alumni clubs, operate a free placement service for alumni, organize special alumni events, furnish a medium through which alumni may aid the president and faculty, aid visiting alumni, help publicize the achievements of Georgia Tech and raise funds for Tech through the annual alumni roll call. The executive director is the central contact for all alumni.

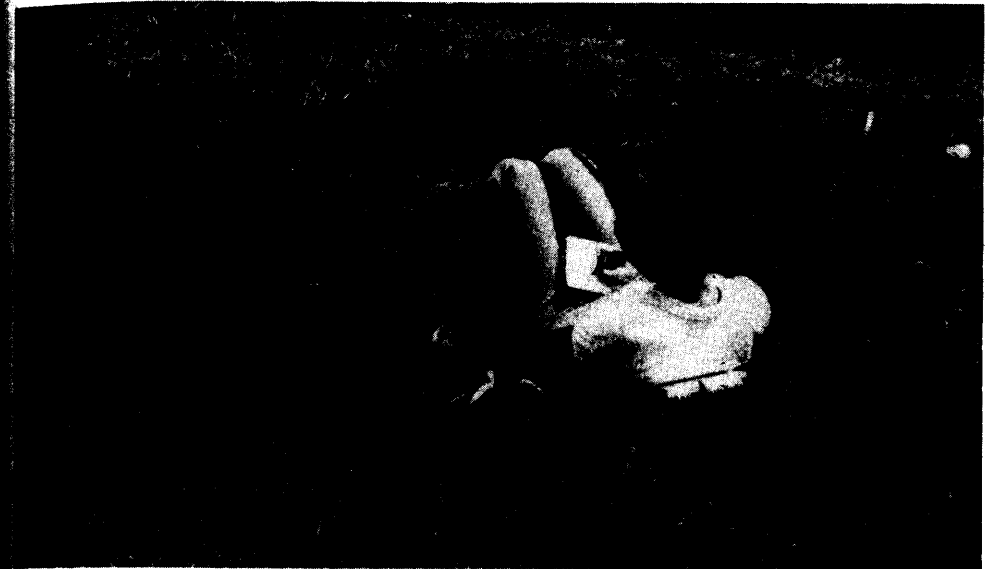
The Georgia Tech Foundation, Inc.

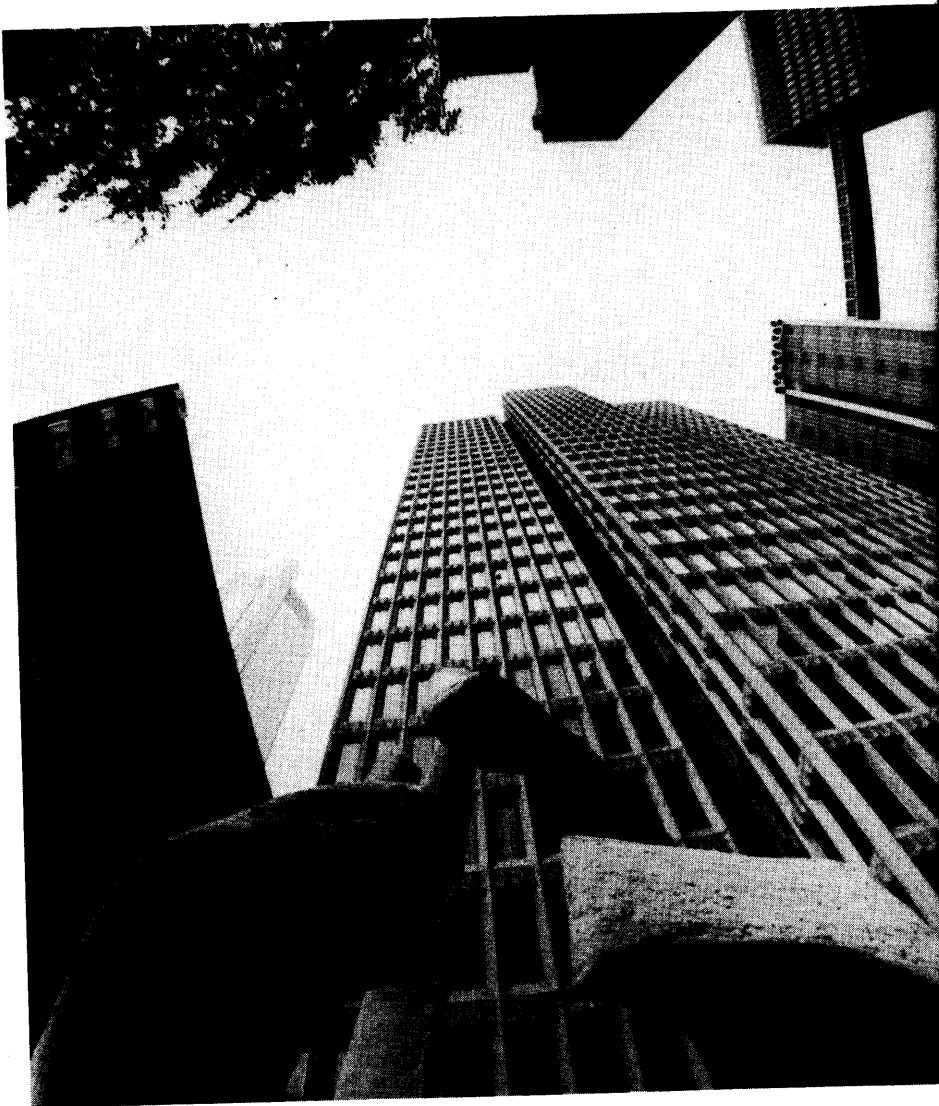
The Georgia Tech Foundation, Inc., is a not-for-profit, tax-exempt corporation which receives, administers and invests virtually all contributions made in support of the Georgia Institute of Technology. The Board of Trustees of the Georgia Tech Foundation, Inc., is composed of thirty-two individuals distinguished by their expertise in financial management, investments, the legal aspects of such organizations and the continuing support of the Institute.

The assets of the foundation include more than \$15 million in endowment and over \$3 million in annual expendable gifts. Allocation of these funds is made on a monthly basis to meet the most pressing needs of the Institute, particularly for faculty salary supplementation, travel and other funding needed to maintain a strong instructional staff; undergraduate and graduate student support, both for need and exceptionally well-qualified students such as National Merit Scholars; and research support, including equipment.

The Georgia Tech Research Institute

This not-for-profit corporation administers and seeks funds for research activity in the administrative divisions of Georgia Tech. It is the coordinating agency for patent applications and other matters related to the protection and use of technological discoveries made at Georgia Tech.



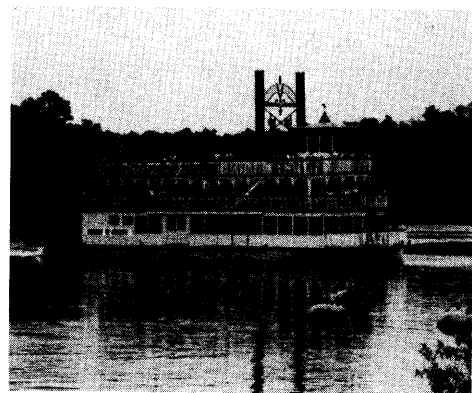
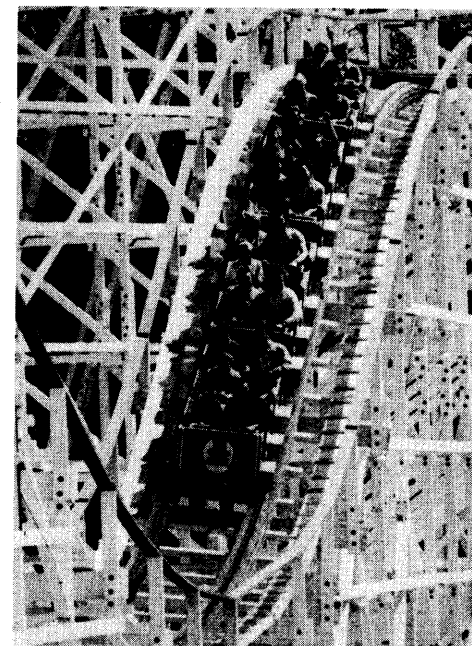
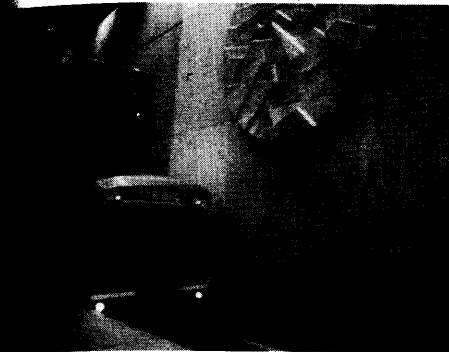


ATLANTA

Atlanta has much to offer as a growing, vibrant community of over a million and a half residents. It is a beautiful and exciting city of government, finance, higher education, art, entertainment, industry and major league sports.

Among the many popular attractions in the Atlanta area are Stone Mountain Park, Six Flags over Georgia, the Atlanta Memorial Arts Center, Lakes Lanier and Allatoona, the Atlanta Zoo, and the Moorish-styled Fox Theatre.

Atlanta's geographic position contributes to its being the transportation, financial and communications hub of the Southeast. Spread over 129 square miles, the city is 1,050 feet above sea level which makes its elevation the second highest of the large U.S. cities, assuring a pleasant year-round climate.



ACADEMIC CALENDAR 1980-81

Georgia Tech operates on the quarter plan with the fall, winter and spring quarters normally constituting the academic year. A full summer quarter is also offered and many students accelerate their program by attending four quarters per year. A program of study may be entered in any one of the four quarters. The requirements for a degree may be completed at the end of any quarter and a commencement ceremony is held at the end of each quarter.

An official Institute calendar is prepared and distributed each quarter by the office of the registrar. Dates, filing times, deadlines and other information included in the official calendar supersede previously published information such as that included in this catalog. Students are responsible for adhering to the requirements set by the official calendar.

Fall Quarter 1980

September 22	Registration
September 24	Classes begin
November 27	Begin Thanksgiving recess
November 30	Last day of Thanksgiving recess
December 8	Final exams begin
December 13	End of term
December 14	Begin Christmas recess

Winter Quarter 1981

January 5	Registration
January 6	Classes begin
March 16	Final exams begin
March 21	End of term
March 22	Begin spring recess

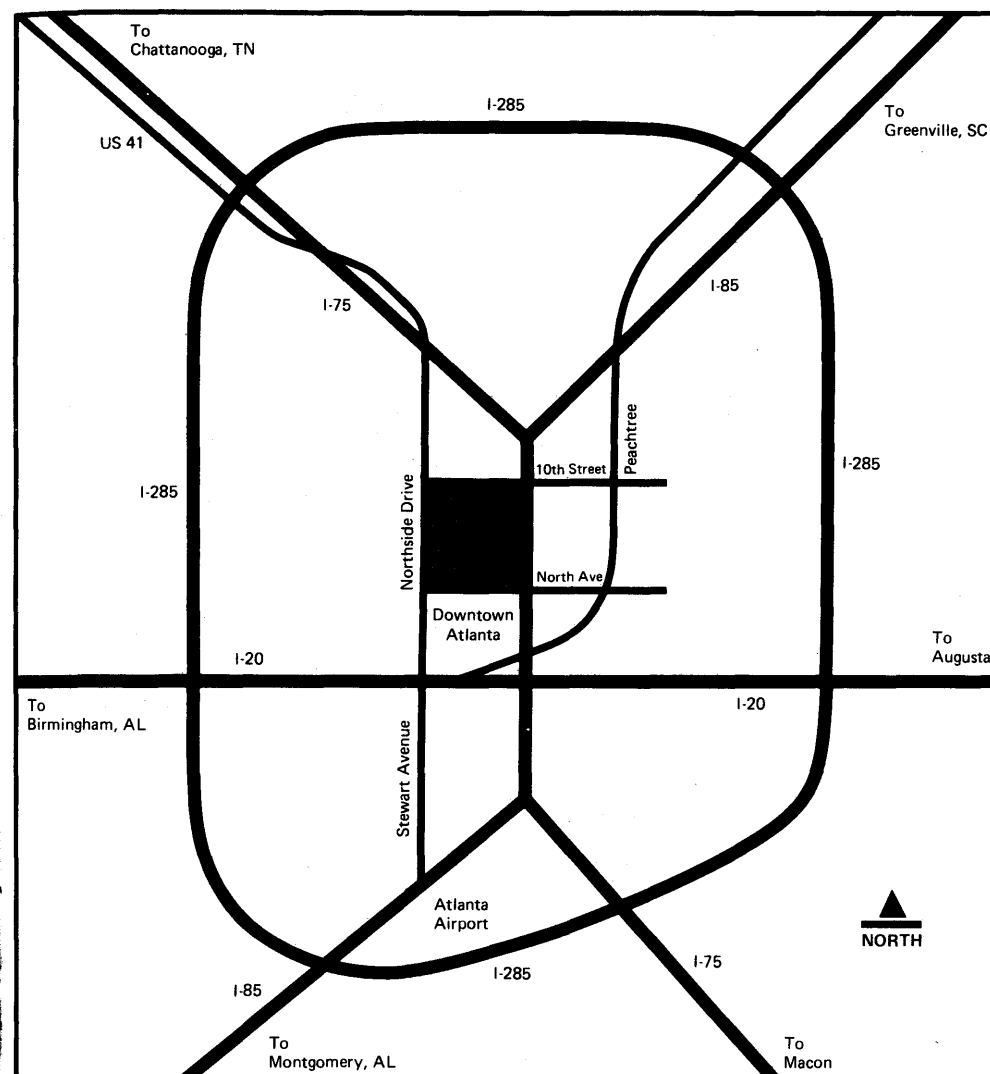
Spring Quarter 1981

March 30	Registration
March 31	Classes begin
June 8	Final exams begin
June 13	End of term

Summer Quarter 1981

June 22	Registration
June 23	Classes begin
August 31	Final exams begin
September 5	End of term

GEORGIA TECH CAMPUS LOCATION



INFORMATION FOR UNDERGRADUATE STUDENTS

DEGREES

The Georgia Institute of Technology at present offers curricula leading to the following undergraduate degrees.

Bachelor of Aerospace Engineering
Bachelor of Ceramic Engineering
Bachelor of Chemical Engineering
Bachelor of Civil Engineering
Bachelor of Electrical Engineering
Bachelor of Engineering Science
Bachelor of Industrial Engineering
Bachelor of Mechanical Engineering
Bachelor of Nuclear Engineering
Bachelor of Textile Engineering
Bachelor of Science
Bachelor of Science in Applied Biology
Bachelor of Science in Applied
Mathematics
Bachelor of Science in Applied Physics
Bachelor of Science in Applied
Psychology
Bachelor of Science in Building
Construction
Bachelor of Science in Chemistry
Bachelor of Science in Economics
Bachelor of Science in Health Physics
Bachelor of Science in Health Systems
Bachelor of Science in Information and
Computer Science
Bachelor of Science in Industrial Design
Bachelor of Science in Industrial
Management
Bachelor of Science in Management
Science
Bachelor of Science in Physics
Bachelor of Science in Textile Chemistry
Bachelor of Science in Textiles

To graduates who have completed their courses under the cooperative plan, the degree is awarded with the designation "Cooperative Plan." Requirements for each degree are listed in "Curricula and Degrees" under the school responsible for the program. Students are encouraged to select a degree program as early as possible, preferably with their request for admission, but the decision may be postponed until a time as late as the end of the sophomore year. Students who have selected a degree program will receive academic advice from the appropriate school. Undecided students are advised through the offices of the deans of the four colleges.

SPECIAL PROGRAMS

The Cooperative Plan

Since 1912 Tech has offered two plans of study in engineering: the standard four-year plan and a five-year cooperative plan for students who wish to combine practical experience with technical theory.

Approximately 2,000 students enrolled in the cooperative program are employed in over 390 industries throughout the country.

The cooperative division offers programs for majors in aerospace, ceramic, chemical, civil, electrical, industrial and systems, mechanical, nuclear and textile engineering, including textiles and textile chemistry, and in chemistry, engineering science and mechanics, information and computer science, mathematics, physics and industrial management. The academic curricula are identical to those offered regular four-year students.



The plan operates on alternating college and industrial quarters. The students are divided into two sections, the first registering in June and the second in September. The co-ops of section one and those of section two alternate between industry and college, exchanging places with each other every three months for four years. At the beginning of the fifth year the two sections merge and remain at college together until graduation in June, when each cooperative student receives a bachelor's degree, co-operative plan, in the student's particular field.

Students in the cooperative division are selected from applicants on the basis of high scholarship.

Practical experience, the primary purpose of the plan, is a valuable asset to young graduates starting out in their chosen professions. Neither college laboratory experience nor practical working experience during summer vacations can take the place of organized co-op training in industry. The plan provides, to a substantial degree, the experience most companies require their engineers to have before promoting them to positions of responsibility.

The work experience is an aid to students who seek employment after graduation. It may also help them decide early in their college careers whether they wish to continue the study of engineering, science or management as a life profession.

The second purpose, understanding the human element, is another important consideration. While working in industry, students come in daily contact with both college and noncollege men and women among their fellow employees. Through working with such diverse groups, students get a practical insight into sociology, ethics, economics and psychology that never could be gotten from textbooks.

A third and significant purpose is financial. Firms that employ cooperative students compensate them for service rendered. Although students are not able to earn all of their college expenses, as a rule they can earn more than half.

Students interested in applying for admission to the cooperative plan should write to Director, Cooperative Division,

Georgia Tech, Atlanta, Georgia 30332, for the division's bulletin, which gives such information as fees, living expenses and wages paid students while at work.

Dual Degree Program

Many high school students are seeking a broadly based educational experience involving the types of college programs generally found at a liberal arts college as well as professional education in technology. Georgia Tech has developed an extensive network of college contacts through the Dual Degree Program to serve their needs. Under this plan the student attends a liberal arts college for approximately three years, then comes to Tech for two years. Upon completion of the program the student receives a bachelor's degree from the liberal arts college and a bachelor's degree from Georgia Tech.

Programs of study at Tech may be centered in any of the various specialty areas of engineering, science, mathematics or management. The colleges participating in the Dual Degree Program include most of the units of the University System of Georgia, the Atlanta University Center Colleges and 79 other colleges and universities throughout the nation. The list of participating colleges is increasing rapidly and includes 10 traditionally black colleges as well as 20 predominantly women's colleges. A Dual Degree Program applicant is considered a transfer student and must meet all requirements for transfer.

ROTC

Georgia Tech has three entirely voluntary ROTC programs: Army, Navy and Air Force. All three programs accept both men and women.

Six hours of basic ROTC and nine hours of advanced ROTC may be used as elective credit toward a degree. Students who earn a baccalaureate or higher degree and successfully complete the advanced ROTC courses of any of the three services are selected for commissioning in either the reserve or the regular forces.

Each ROTC unit offers scholarship programs of two, three and four years. All

juniors and seniors selected for the advanced courses receive a substantial monetary allowance each month while enrolled in ROTC.

Preprofessional Programs

Premedical, pre dental and prelaw programs are offered at Georgia Tech. None of these is specified as a degree program as such, but students who take the proper courses from the various curricula will attain the objectives usually associated with these programs.

To obtain a prelaw background, a bachelor's degree in almost any engineering or management area or a degree in psychology would be most acceptable. The Institute has a prelaw adviser in the College of Management, the School of Health Systems and the School of Industrial and Systems Engineering. Students are encouraged to consult with the appropriate adviser regarding their plans for meeting law school entrance requirements.

The student considering a career in medicine or dentistry may meet the normal subject requirements for entrance to medical or dental school under the degree programs in the sciences or engineering.

Quite often students declare a major in biology for a premedical background since the courses taken routinely in the biology curriculum include all the subjects listed in the *Medical School Admissions Requirements, USA and Canada*.

Another highly recommended major for premedical or pre dental students is health systems. This curriculum forms an excellent background and it provides the systems orientation now being favored by leading medical educators. By selecting the premedical option, the entrance requirements of most medical and dental schools can be completed with the framework of the health systems curriculum. This major has the added advantage of keeping a college student's options open throughout the undergraduate level for possible future employment in any number of challenging and rewarding careers in the health-care field, rather than serving solely as a premedical or pre dental major.

Premedical and pre dental requirements

can be met in other science and engineering majors at Georgia Tech. By using carefully chosen electives, one can major in chemistry, chemical engineering, electrical engineering, engineering science and mechanics, industrial and systems engineering, mechanical engineering, physics or psychology. With the flexibility now available in electives, it is also possible to major in other areas of engineering.

Each premed and pre dental student is advised to consult early in his or her college career with the Institute's premedical advisory committee for information about general and specific requirements.

Joint Enrollment Program for High Schoolers

Georgia Tech admits a limited number of gifted students who have finished the eleventh grade and who have academic credentials that would place them in the upper part of Tech's freshman class.

Students admitted in this category will normally take all their course work at Tech. The courses taken will include those subject areas needed to fulfill the high school requirements for graduation. High school credit is given for such courses, and the student actually graduates with his or her high school class. All work taken at Georgia Tech is also applicable toward an Institute degree if it is a part of a particular curriculum undertaken by the student at a later date.

To be eligible to participate in this program, the local school system must have signed the appropriate agreement with the Georgia Institute of Technology. Students should check with local school officials to determine if their particular system is a participating member. If so, the student should check with the high school counselor regarding specific course, test and recommendation requirements for JEPHS. If further information or assistance is required, contact the admissions office at Georgia Tech.

Special Studies

Georgia Tech is dedicated to helping each student realize his or her full academic po-

tential. For this purpose a variety of programs present different approaches to aid in overcoming academic stumbling blocks. Each of the programs is based on voluntary participation by students needing the services available.

A mathematics laboratory is available in which any Georgia Tech student needing help with a freshman level mathematics course may obtain tutoring. The laboratory is operated by the mathematics department afternoons Monday through Friday during weeks when classes are in session.

A laboratory course conducted by the English department in the mechanics of reading is designed for students who desire to increase their reading speed and improve their comprehension of written material.

English and literature for international students are courses designed for students whose native language is not English. They are intended to introduce international students to written and spoken English as well as American social situations, customs, ideas and literature.

English for students who fail the regents' examination is a special course taught for students who desire further preparation before retaking it.

STEP is a service from which students may obtain help with any freshman level course. This help is in the form of quick answers to telephoned questions on current assignments, short personal tutoring sessions and occasional group coaching in particularly troublesome areas. STEP is coordinated through the office of the dean of engineering.

ADMISSIONS

For any information regarding admission to Georgia Tech, write to the:

Director of Admissions
Georgia Institute of Technology
Atlanta, Georgia 30332

Both freshman and transfer students are accepted for all four academic quarters, which begin in September, January, March and June.

Freshmen student deadlines for submission of the Application for Admission and all required credentials are as follows:

Quarter	Residents	Nonresidents
Summer	April 1*	January 1
Fall	April 1*	January 1
Winter	December 1	December 1
Spring	March 1	March 1

Transfer student deadlines for submission of the Application for Admission and all required credentials are as follows:

Quarter	Residents	Nonresidents
Summer	April 1*	April 1
Fall	June 1*	June 1*
Winter	December 1	December 1
Spring	March 1	March 1

*January 1 for residents seeking financial aid.

Transfer students should plan their transfer so as to allow ample time for official final transcripts from their previous school to be sent to Georgia Tech. If official final transcripts have not been received prior to the last day of registration, the student seeking transfer will not be allowed to complete registration.

Detailed policies, procedures and information concerning requirements for consideration, admissions decisions, notification of applicants and acceptance deposits; financial aid, cooperative plan and housing applicants; Joint Enrollment, Dual Degree, Early Admissions and Early Notification; and the entire range of admission details is covered in the *Admissions Catalog* which is specifically designed to present all information needed by applicants up to the point of enrollment at Georgia Tech.

Admission of International Students

A special information pamphlet for foreign students is available upon request which indicates the application procedures for undergraduate freshmen and transfers and other basic information helpful to applicants from other countries. In general, international students are accepted for fall quarter only.

Advanced Placement and Honors Program

Superior students entering Georgia Tech may receive college credit for courses completed in high school if their scores on the college board advanced placement program examinations indicate a satisfactory knowledge of college course work. Advanced placement and credit are offered by the Schools of Chemistry, Mathematics, Physics and Social Sciences and by the Department of English. Minimum AP score for consideration in English, mathematics or history is three. The minimum in chemistry or physics is four.

Advanced placement is possible in chemistry on the basis of high scores on the college board achievement tests. A number of students in the engineering college whose scores on the SAT-verbal and the English achievement test examinations are sufficiently high are given the option of waiving one or more of the freshman courses as prerequisites to enrollment in the upper-level courses offered by the English department. An honors program is offered in mathematics. Participation in advanced placement, advanced sectioning and honors programs is voluntary.

Under certain conditions, up to 12 hours of credit for high school language study is granted by the Department of Modern Languages. See page 136.

Veterans Program

As early as possible, and preferably at least one month before entering Georgia Tech, any student planning to enroll under any of the Veterans Administration programs should visit the financial aid office on the Georgia Tech campus to initiate enrollment certification procedures. The veteran being certified for the first time should bring such items as proof of discharge (DD-214). Veterans previously certified must have their VA claim number. Eligible veterans will be certified in advance of enrollment in order to expedite the first benefit check. Students who request enrollment certification on the day of registration should anticipate a four to six week delay in the receipt of the first benefit check. All

questions regarding procedures for certification should be directed to the Office of Financial Aid located on the ground floor of the Administration Building on the Georgia Tech campus.

The veteran planning to study using veterans' benefits at the Georgia Institute of Technology should apply for admission as any other student. Eligibility for Veterans Administration benefits has no direct relationship to the institution. All financial transactions are directly between the student and the Veterans Administration. The institution serves only as a source of certification and information to the Veterans Administration.

Most veterans who served on active duty for more than 180 days, any part of which occurred after January 31, 1955 and before January 1, 1977, are generally eligible for financial support to attend college.

Generally, sons and daughters between 18 and 26 years old of deceased veterans, those of living veterans who have disabilities which are considered to be total and permanent, and those of veterans whose death or disability was a result of service in the armed forces are eligible for financial benefits to attend college. Applicants in these categories should ask their local Veterans Administration office for complete details.

The local Atlanta Veterans Administration address is 730 Peachtree Street, NE, Atlanta, Georgia 30308.

Readmissions

Georgia Tech students who find it necessary to discontinue enrollment for one or more quarters, with the exception of a summer quarter, must apply for readmission when planning to return to the Institute. An application for readmission may be obtained from the registrar and must be completed and returned no later than the date indicated by the following schedule:

Quarter	Date
Fall	August 1
Winter	December 1
Spring	March 1
Summer	June 1

Additional information is available in the section on "Rules and Regulations."

Academic Advising

The faculty of each school has the obligation to provide each student enrolled in that school the opportunity to obtain consultation on his or her academic program and to receive advice on course selection. Students are encouraged to seek assistance from their faculty advisers whenever a problem occurs concerning their academic programs. A student who does not know the identity of the faculty adviser should seek assistance from the school director.

ACADEMIC REGULATIONS

Detailed information regarding the academic regulations of the Institute is contained in this catalog, under "Rules and Regulations." Questions concerning academic regulations should be directed to the general office of the student's major school or to the registrar, room 104, Administration Building.

Grading System

Detailed information regarding the grading system is contained in this catalog under "Rules and Regulations," section IV.

Institute Rules for the Pass-Fail System

At the option of the student's major school, up to a maximum of 12 hours credit toward a bachelor's degree or six hours credit toward a graduate degree may be allowed for courses taken under the pass-fail system, with a grade of "pass." The department or school offering a course may, if it desires, restrict enrollment on a pass-fail basis. In order that credit for a particular course taken on the pass-fail system be counted toward the degree requirements, the student's major school must approve the course. Approval may be given on an individual basis or a school may establish blanket rules for its majors. Courses taken under the pass-fail system will not be included in the calculation of the grade point

average, whether the grade be pass or fail. Withdrawal from courses taken on a pass-fail basis will be handled under the same rules as for courses taken on a graded basis.

Students who register under the pass-fail system will be so designated on the official class rolls and the only grade that will be recorded is a "pass" or a "fail." The criteria for a grade of "pass" are determined by the department or school offering the course. Under no circumstances will the basis for registration be changed from credit to pass-fail or from pass-fail to credit after the last day to make schedule changes. In no event will a pass-fail grade be changed at a later time to a letter grade. It is recognized that there will be times when, due to changes in the degree requirements, a course for which degree credit could be earned on a pass-fail basis at the time the course was taken will not be acceptable at a subsequent time. In such cases the student's major school will decide if a course taken with a grade of "pass" will be accepted in fulfillment of the degree requirement.

Only students who complete 180 or more hours toward a degree at Georgia Tech may use the entire maximum of 12 hours credit taken on pass-fail toward a bachelor's degree. The maximum number of hours of pass-fail allowed for transfer students, second undergraduate degree students and dual degree students is determined by the number of hours completed at Georgia Tech according to the following schedule.

Hours included in program of study	Hours allowed on pass/fail basis
50 to 89 credit hours	3 credit hours
90 to 134 credit hours	6 credit hours
135 to 179 credit hours	9 credit hours
180 or more credit hours	12 credit hours

Examination and Grade Reports

Final examinations are scheduled during the last week of each quarter and grade reports of the student's academic progress are issued after the close of the quarter.

Scholastic Average

A student who passes a course receives a number of quality points equal to the product of the course credit hours and the numerical equivalent of the letter grade received (A = four, B = three, C = two, D = one). Thus, a student taking a three hour credit course and earning a grade of C receives six quality points. The scholastic average of an undergraduate student is calculated by dividing the total number of quality points earned by the student on all courses scheduled as an undergraduate student by the total number of credit hours scheduled. The scholastic average for a graduate student is calculated in a similar manner using all courses scheduled as a graduate student while enrolled in the graduate division. The grade received in a course is not replaced by a higher or lower grade in the same course taken again. Both grades are used in the computation of the scholastic average. Courses taken under the pass-fail system will not be included in the calculation of the grade point average, whether the grade be pass or fail.

Transfer Credit

The basic policy regarding the acceptance of courses by transfer is to allow credit for courses completed with satisfactory grades (C or better) in other accredited colleges provided the courses correspond in time and content to courses offered at the Georgia Institute of Technology. In no case will credit be allowed (except by examination) for courses completed at another institution that have previously been failed at Georgia Tech. An official transcript, requested by the student, must be on file in the office of the registrar before credit can be awarded.

Enrolled students at Georgia Tech must receive prior approval from the student's major school and the registrar before scheduling courses at other institutions.

Auditors

Any officially enrolled student who has obtained the approval of his or her adviser and the departments of instruction concerned may audit courses. No credit is

granted for courses scheduled on an auditing basis, however, and students are not permitted to change to or from an auditing status except through the regular procedures for schedule changes and during the period for changes as published in the official calendar for each quarter. All students registered as auditors are required to pay tuition at the regular rate. Members of the faculty or staff of the Georgia Institute of Technology may sit in on a course providing permission is obtained from the department concerned and the registrar.

Constitution and History Examinations

The Georgia law as amended March 4, 1953 requires that before receiving an undergraduate degree all students pass examinations or pass comparable courses in United States and Georgia history as well as United States and Georgia Constitution. Courses which may be substituted for the United States and Georgia Constitution requirement are Pol. 1251 or Pol. 3200. Courses which may be substituted for the United States and Georgia history examinations are Hist. 1001, Hist. 1002, Hist. 3010 or Hist. 3011.

Regents' Testing Program

A requirement which every student in the University System of Georgia (of which Georgia Tech is a part) must meet in order to be eligible for an undergraduate degree is the passing of an examination designed to measure proficiency in reading and English composition. This examination, known as the Regents' Test, is to be taken before the end of the sophomore year. If failed, it may be repeated. It must be passed before graduation. Students who reach 105 hours credit toward a degree and who have not passed the Regents' Test will be required to schedule remedial English along with other credit course work.

Major Area Examinations

All students completing requirements for baccalaureate degrees are required by the University System of Georgia to take a ma-

for area examination prior to being certified as having completed all requirements for the degree.

ROTC Credit

Six quarter hours in basic ROTC courses and nine quarter hours in advanced ROTC courses are the maximum credits allowed toward meeting the requirements for any degree. See "Rules and Regulations."

Physical Education

All students entering Georgia Tech are required to satisfactorily complete three credit hours in physical education courses. It is expected that this requirement will be completed during the student's freshman year. Unless medically disqualified, all students will be required to complete swimming (P.E. 1010) plus two additional courses. One of these must be selected from the remaining courses at the 1000 level and one must be selected from the 2000 level.

The health information record will determine any medical exemptions from physical education courses. All certificates of disability from personal physicians must be endorsed by the Student Health Services before they will be accepted by the department.

Students who are exempt for medical reasons from all physical education activity courses will be required to satisfactorily complete P.E. 1040 (Health Education) to complete their physical education requirement. Students who are medically exempt from a single 1000 level course including swimming must substitute an additional 1000 level course in its place.

Transfer students will be granted credit for comparable physical education courses completed at other institutions.

Students who are 25 years of age or older upon matriculation to the Institute have the option of satisfying the physical education requirement for graduation by completing the regular physical education requirements or by satisfactorily completing P.E. 1040.

See the section on Physical Education for a listing of the courses and categories.

Humanities and Social Sciences Requirements

A tabulation of the work required for degrees in the curricula offered by the Georgia Institute of Technology is given in this catalog under "Curricula and Degrees."

At least 36 credit hours of humanities and social sciences must be included in all curricula leading to an undergraduate degree.

Students in all degree programs must take at least 36 hours of humanities and social sciences distributed as follows.

At least 18 hours of humanities (including at least three hours of literature) selected from the following subjects:

English: 1001, 1002, 1003, 1033, 2001, 2002, 2003, 2004, 2007, 2010, 2031, 2032, 2033, 2037, 2038, 2039, 3006, 3008, 3037, 3038, 3039, 3041, 3042, 3043, 3044, 3051, 3052, 3056, 3058, 3059, 3061, 3062, 3072, 3075, 3076, 3081, 3082, 3083, 3084, 3085, 3086, 3141, 3161, 3261, 3361, 3760, 3761, 3786, 4041, 4042, 4043, 4044, 4051, 4081, 4082, 4083, 4755, 4801, 4803, 4811, 4813, 4821, 4823.

Modern Languages:¹

¹French, Spanish, Russian, German 1001, 1002, 1003.

¹Foreign Languages: 1001, 1002, 1003, 1011, 1012, 1013, 1021, 1022, 1023.

German: 3001, 3002, 3003, 3004, 3031, 3032, 3033, 3041, 3042, 3043, 3051, 3760, 4001, 4002, 4003, 4021, 4022, 4023, 4051, 4052, 4053, 4091, 4901.

Russian: 3001, 3002, 3003, 3761, 4901.

¹Students in the Engineering College may include up to nine hours of 1000 level foreign language courses (twelve hours in Russian) for humanities credit, provided that they complete nine additional hours in the same language on the 2000 or higher levels; otherwise the 1000 level courses will count as free electives. This regulation does not apply to linguistics courses. (Note: All nine hours at the 2000 or higher levels must be completed at Georgia Tech.)

Spanish: 3001, 3002, 3003, 3006, 3011, 4021, 4022, 4023, 4024, 4025, 4026, 4031, 4032, 4091, 4901.

French: 2021, 2022, 2023, 3001, 3002, 3003, 4001, 4002, 4003, 4091, 4901.

²Linguistics: 1001, 1002, 1003, 2001, 2002, 2003, 3001, 3002, 3003, 3004, 4002, 4003, 4901.

Music: 2001, 2003, 2201, 2202, 2203, 3201, 3202, 3203.

Architecture: 1201, 1202, 1203, 3201, 3202, 3203, 3204, 3205, 4204, 4205, 4206, 4207, 4208, 4209, 4241, 4242, 4243, 4247, 4248, 4249.

Industrial Design: 1261, 1262, 1263.

At least 18 hours of social sciences (including at least three hours of history and three hours of American government) selected from the following subjects:

History: 1001, 1002, 1028, 3001, 3003, 3004, 3010, 3011, 3012, 3013, 3015, 3016, 3017, 3018, 3020, 3022, 3024, 3025, 3026, 3028, 3030, 3037, 3038, 3039, 3040, 3786, 4008, 4016, 4025, 4050, 4075, 4925, 4926, 4927, 4928, 4929.

Philosophy of Science and

Technology: 1126, 1127, 3100, 3102, 3103, 3104, 3105, 3107, 3120, 3121, 3122, 4106, 4107, 4110, 4115, 4944, 4945, 4946, 4947, 4948, 4949.

Political Science: 1251, 1253, 2270, 2271, 3200, 3203, 3204, 3205, 3210, 3211, 3215, 3216, 3217, 3220, 3221, 3222, 3250, 3265, 3266, 3270, 3275, 3276, 3280, 3281, 4200, 4201, 4202, 4210, 4211, 4250, 4755, 4950, 4952, 4953, 4954, 4955, 4956.

²Linguistics 3001, 3002, 3003 may not be used as humanities by students in the College of Engineering.

Sociology: 1376, 1377, 1378, 3306, 3310, 3330, 3334, 3335, 3338, 3339, 3340, 4306, 4308, 4311, 4312, 4750, 4999.

Modern Languages:

Foreign Languages: 2011, 2012, 2013, 2021, 2022, 2023.

German: 2001, 2002, 2003, 2051, 2052, 2053, 3011, 3012, 3013, 4092, 4093, 4902.

French: 2001, 2002, 2003, 3011, 3012, 3013, 3021, 3022, 3023, 4092, 4093, 4902.

Russian: 2001, 2002, 2003, 4902.

Spanish: 2011, 2012, 2013, 3004, 3005, 3007, 3008, 3009, 3012, 4007, 4008, 4009, 4010, 4092, 4093, 4902.

Linguistics: 4001, 4902.

Psychology: 3300, 3303, 3304, 4400, 4402, 4410, 4423, 4424, 4750, 4755.

Economics: 2000, 2001, 3000, 3001, 3002, 3400, 3500, 3501, 3502, 4300, 4332, 4340, 4341, 4400, 4420, 4500.

³Sociotechnology:

Civil Engineering: 4143.

Nuclear Engineering: 4620.

³To be used by students in the Engineering College only.

FINANCIAL INFORMATION

Costs

	Resident of Georgia	Nonresident of Georgia
Quarterly Fees		
Matriculation Fee	\$236.00	\$236.00
Nonresident Fee	\$ 0.00	\$550.00
Transportation Fee	\$ 3.50	\$ 3.50
Student Activity Fee	\$ 24.00	\$ 24.00
Health Service Fee	\$ 28.00	\$ 28.00
Total	\$291.50	\$841.50
Books and Supplies	\$80	\$80
Room Rent	\$240-280	\$240-280
Board	\$370-410	\$370-410
Personal Expenses (clothing, laundry, recreation, etc.)	\$175	\$175
Total Per Quarter	\$1160-1240	\$1710-1790
Total Per Year (3 quarters)	\$3480-3720	\$5130-5370
Total Per Year (2 quarters) for co-op students in school 2 quarters instead of 3	\$2320-2480	\$3420-3580
Additional Freshman Expenses pocket calculator, drawing sup- plies (in addition to quarterly costs)	\$150	\$150
Total per year freshmen only	\$3630-3870	\$5280-5520

Part-time students (those carrying less than 12 credit hours per quarter) who are legal residents of Georgia will be charged \$20 per credit hour. Nonresidents will be charged \$66 per credit hour. All students scheduling six hours or more must pay the transportation, student activity and health service fees of \$55.50.

The above expenses do not include fraternity, club dues or personal transportation expenses. Since changes in fees may occur without notice, the student must refer to information provided on registration day by the Office of the Vice-president for Business and Finance for official amounts on fees and other institutional charges for each individual quarter. An extra fee may be charged in special courses.

A deposit (in addition to the dormitory

room deposit) is required of each accepted applicant for admission to the fall quarter as required in the letter of admission. Approximately two weeks following registration, this deposit will be refunded to the student by check mailed to his or her campus post office box. Any student who withdraws during the first quarter of his or her attendance may have his or her admission deposit deducted before any computation is made of the refund to which the student may be entitled.

Obligations of Students

An individual is not officially enrolled at Georgia Tech until all tuition, matriculation, student activity and medical fees for the current quarter are paid. Once enrolled, every student is obligated to remit, return

or submit all other financial obligations that may become due, as well as property or records of the Institute, within the time prescribed by the Institute. Failure to fulfill any such obligation will result in denial of registration privileges for subsequent quarter(s). Such denial of registration privileges is in addition to and apart from any disciplinary measures which may be taken pursuant to the Student Conduct Code, *Student Rules and Regulations*.

Other Fees

Each person receiving a diploma must pay a diploma fee before graduating.

Examinations at other than regular examination times will be granted in exceptional cases only and by faculty action. Normally a fee will be charged in such cases.

A late registration fee of not more than \$14 is charged at the rate of \$10 for the first day after regular registration, and an additional \$2 for each of the next two days. If a student does not pay all required fees by the end of the first week of the quarter, his or her registration will be cancelled.

Refund of Fees

Refunds of fees for reasons of withdrawal from the Institute or dropping of subjects may be considered only upon written application to the business office. The application must be dated and signed by the individual requesting the refund.

A form is available from the registrar or the cashier's office to request the refund. A copy of the withdrawal application or drop slip must accompany the refund application.

The following refund schedule applies:

Courses dropped or withdrawal from school effected	Percent Refunded
One week following registration	80%
Two weeks following registration	60%
Three weeks following registration	40%
Four weeks following registration	20%

Students who withdraw or drop a subject after a period of four weeks has elapsed from the scheduled registration date will not be entitled to a refund of any part of fees paid for that quarter. All requests for refunds must be received in the Office of the Vice-president for Business and Finance within one month following the registration date. Requests for dormitory rent refunds must be completed at the Housing Office by the individual.

Definition of Legal Residence

Because the overwhelming proportion of financial support for the operation of the public institutions of higher education in Georgia comes from the citizens through the payment of taxes, the determination of whether a student is classified as a resident or a nonresident of the state is a significant matter. The fees paid by resident students cover only about one-fourth of the total cost of their education in the university system. Therefore, Georgia taxpayers are contributing three-fourths of the necessary funds to provide quality education for the citizens of the state.

The practice followed by state colleges and universities of assessing nonresident students a higher tuition rate is a rational attempt by states to achieve a partial cost equalization between those who have and those who have not recently contributed to the state's economy, even though there is no way to determine the degree to which higher tuition charges equalize the cost of educating residents and nonresidents. The durational residency requirement (usually 12 months) imposed by most, if not all, states is considered by the courts to be a reasonable period during which the new resident can make tangible or intangible contributions to the state before being allowed the benefit of attending state colleges upon the payment of resident fees.

The foregoing considered, the board of regents has adopted the below listed policies governing the classification of students as residents and nonresidents in keeping with its responsibility to the citizens of Georgia for an appropriate assessment of nonresident fees to insure that

out-of-state students pay a fair and reasonable share of the cost of their education.

1. (a) If a person is 18 years of age or older, he or she may register as a resident student only upon a showing that he or she has been a legal resident of Georgia for a period of at least 12 months immediately preceding the date of registration. (b) No emancipated minor or person 18 years of age or older shall be deemed to have gained or acquired in-state residence status for fee purposes while attending any educational institution in this state, in the absence of a clear demonstration that he or she has in fact established legal residence in this state.

2. If a person is under 18 years of age, he or she may register as a resident student only upon a showing that his or her supporting parent or guardian has been a legal resident of Georgia for a period of at least 12 months immediately preceding the date of registration.

3. A full-time employee of the University System and his or her spouse and dependent children may register on the payment of resident fees.

4. Nonresident graduate students who hold teaching or research assistantships requiring at least one-third time service may register as students in the institution in which they are employed on payment of resident fees.

5. Full-time teachers in the public schools of Georgia and their dependent children may enroll as students in the university system institutions on the payment of resident fees.

6. All aliens shall be classified as nonresident students; however, an alien who is living in this country under a visa permitting permanent residence shall have the same privilege of qualifying for resident status for fee purposes as a citizen of the United States.

7. Foreign students who attend institutions of the university system under financial sponsorship of civic or religious groups located in this state may be enrolled upon the payment of resident fees, provided the number of such foreign students in any one institution does not exceed the quota ap-

proved by the board of regents for that institution.

8. If the parents or legal guardian of a minor changes his or her legal residence to another state following a period of legal residence in Georgia, the minor may continue to take courses for a period of 12 consecutive months on the payment of resident fees. After the expiration of the 12 month period the student may continue his or her registration only upon the payment of fees at the nonresident rate.

9. In the event that a legal resident of Georgia is appointed as guardian of a nonresident minor, such minor will not be permitted to register as a resident student until the expiration of one year from the date of court appointment, and then only upon proper showing that such appointment was not made to avoid payment of the nonresident fees.

10. Career consular officers and their dependents who are citizens of the foreign nation which their consular office represents, and who are stationed and living in Georgia under orders of their respective governments, shall be entitled to enroll in university system institutions on payment of resident fees. This arrangement shall apply to those consular officers whose nations operate on the principle of educational reciprocity with the United States.

11. Military personnel and their dependents stationed in Georgia and on active duty, except military personnel assigned to system institutions for educational purposes, shall pay the same fees assessed residents of Georgia.

Procedure for handling: this will be handled on a quarter-to-quarter basis as a waiver rather than a reclassification. Waivers may be obtained from the Residency Office, Room 101, Administration Building by presenting a copy of military assignment orders and fee card. Military personnel on temporary assignment will not be eligible for this waiver.

If there is any question concerning residence status, students should contact the Residency Office, Room 101, Administration Building in writing or by telephone (404/894-4612). Applications for classifi-

cation as a legal resident for fee payment purposes must be received by the Residency Office not later than one month prior to the academic registration date for the quarter in which the student seeks admission as a resident of Georgia.

Undergraduate Financial Aid

Financial aid at the Georgia Institute of Technology is intended to assist as many students as possible to meet normal college expenses. No student should fail to consider attending Georgia Tech because of financial reasons. Georgia Tech will aid students either through school funds or by directing the student to other sources. The financial aid applicant should realize, however, that the amount of aid that can be granted seldom meets all educational expenses, and financial assistance will have to be supplemented by the student, family or other outside sources.

The Financial Aid Office has the responsibility of administering all funds provided to Georgia Tech for the assistance of undergraduate students. It also receives and assigns awards forwarded to the institution from outside agencies for the use of individual students.

All entering students, including transfer students, who wish to be considered for scholarships, grants, loans and/or work opportunities for any quarters of the academic year beginning in September should submit a Georgia Institute of Technology financial aid application prior to February 15. (A Financial Aid Form should be submitted to the College Scholarship Service no later than February 1.) Financial aid awards to entering students are normally made prior to May 1.

Although the cooperative program at Georgia Tech is not a financial aid program, many of those who attend are able to assist themselves with their college expenses through this program. Approximately one-fifth of the undergraduate enrollment attends under the cooperative plan and earns from \$4,000 to \$6,000 per year. Co-op enrollment is restricted to students in the fields of engineering, science

and management. Since financial aid is not a prerequisite for consideration, a student attending under the cooperative plan will not be denied consideration for other aid because of his or her enrollment. Students desiring other information on the cooperative program should write to the director of the Cooperative Division, Georgia Institute of Technology, Atlanta, Georgia 30332.

Many students obtain part-time employment at Tech or in the Atlanta area. Georgia Tech's placement center attempts to keep an up-to-date listing of opportunities and most students will be able to help themselves through part-time employment if they so desire.

The primary purpose of financial aid at Georgia Tech is to provide assistance to students who, without such aid, would be unable to attend college.

The primary responsibility for financing an education rests with the student and his or her family. Any financial aid is, therefore, awarded according to individual need and individual college costs. Financial aid includes scholarships, grants, loans and employment, which may be offered to students singly or in combination.

The family of the applicant is expected to make a maximum effort to assist the student with college expenses. Financial assistance from colleges and other sources should be viewed only as supplementary to the efforts of the family.

The student also has a responsibility to contribute to his or her college expenses through such sources as savings, summer earnings and contributions from friends and relatives. Students receiving aid are expected to use part of their summer earnings to defray college costs.

Students applying for financial aid should have their applications for admission on file by January 1 preceding the fall or summer they expect to enter. For full consideration, the financial aid applicant must be accepted by the admission office no later than February 1.

Applications for financial aid may be obtained by calling or writing the Director of Financial Aid, Georgia Institute of Technology, Atlanta, Georgia 30332.

(404) 894-4160. Requests for further information on any programs of aid should also be directed to the above address. A current *Undergraduate Financial Aid* bulletin, which lists all awards and all applicable procedures and regulations, will be sent upon request.

Medals and Prizes

Awarded by fraternities, academic schools and departments, professional groups and community organizations—medals and prizes, such as the Phi Kappa Phi award, are presented at the annual Honors Day exercises or at the term's end.

INFORMATION FOR GRADUATE STUDENTS

GENERAL INFORMATION

The faculty of the Georgia Institute of Technology grants advanced degrees in engineering, science, management, architecture and city planning. The goals of the Office of Graduate Studies and Research are to establish an educational environment that will encourage and assist students to develop their capabilities both as professionals and as human beings, to encourage students and faculty to press research vigorously for the discovery and generation of new knowledge, to investigate ways of applying such knowledge innovatively for the benefit of society and mankind, and to foster the development of new tools, objects and ideas.

Graduate study is particularly recommended for those students whose interests and aptitudes carry them beyond routine application. It may be undertaken either to broaden knowledge of a given field or to increase competence and interest in independent research. It is for the student who wishes to work in research, development, design, or consulting; it is for the student of management who aspires to the formulation as well as the administration of policy, and it is for those who desire to enter the profession of education in the fields of engineering, science or management.

DEGREES AND PROGRAMS OF STUDY

Doctoral Programs

Programs of study and research leading to the Ph.D. degree are offered in the following disciplines and areas:

- Aerospace Engineering
- Atmospheric Sciences
- Ceramic Engineering
- Chemical Engineering
- Chemistry
- Civil Engineering and Sanitary Engineering
- Economics
- Electrical Engineering
- Engineering Science and Mechanics
- Geophysical Sciences
- Industrial and Systems Engineering
- Information and Computer Science
- Management
- Mathematics
- Mechanical Engineering
- Metallurgy
- Nuclear Engineering
- Operations Research
- Physics
- Psychology
- Textile Engineering and Science

Master's Programs

Programs of study and research leading to the Master of Science degree are offered in the following disciplines:

- Aerospace Engineering
- Applied Physics
- Architecture
- Atmospheric Sciences
- Biology

Ceramic Engineering
 Chemical Engineering
 Chemistry
 City Planning
 Civil Engineering
 Electrical Engineering
 Engineering Science and Mechanics
 Geophysical Sciences
 Health Physics
 Health Systems
 Industrial and Systems Engineering
 Information and Computer Science
 Management
 Mathematics
 Mechanical Engineering
 Metallurgy
 Nuclear Engineering
 Operations Research
 Physics
 Psychology
 Sanitary Engineering
 Technology and Science Policy
 Textile Chemistry
 Textile Engineering
 Textiles

See detailed description of programs and courses under appropriate school designations.

Degrees may be awarded with or without designation of the field, based upon the recommendation of the school concerned.

The Department of City Planning also offers joint programs with the School of Civil Engineering, the College of Architecture and the University of Georgia School of Environmental Design. Each of these joint programs leads to the simultaneous awarding of two master's degrees.

The School of Health Systems offers options in health systems analysis and health systems planning, both of which lead to the degree, Master of Science in Health Systems. Also available are various interdisciplinary and interinstitutional programs through the Health Systems Research Center and the Medical College of Georgia.

SPECIAL PROGRAMS

Interdisciplinary Programs

All graduate degrees are offered through the administrative channels of the several schools of the Institute authorized to offer such degrees. Within this framework, however, arrangements are available for offering special study and research programs for students who desire to pursue a degree with a wider perspective than that of a single discipline.

Programs of this type are available through cooperation with the bioengineering, environmental resources and health systems research centers and through several informal programs based on interests of small groups of faculty in such areas as atomic collisions, complex systems design, radiological health, solid waste technology, transportation and surface science technology. Also see the multidisciplinary programs listed by the College of Engineering on page 71.

The Academic Common Market

The Institute participates in the Academic Common Market Program managed by the Southern Regional Education Board. The market is an interstate agreement among southern states for sharing academic programs. Residents of the participating states who qualify for admission and who are approved by their state coordinators may enroll on an in-state tuition basis. Georgia Tech programs offered on this basis include ceramic engineering, city planning, geophysical sciences, health systems, nuclear engineering and textile engineering.

Courses for Secondary School Teachers

Recognizing that the systems of secondary and higher education in the state of Georgia are mutually supportive, Georgia Tech offers a limited number of courses at the graduate level designed to prepare high school teachers to provide instruction in selected areas of architecture, science, engineering and technology. Courses are restricted to areas uniquely available, or

available in unusual strength, at Georgia Tech.

Credit for satisfactory performance is recorded in the Office of the Registrar in the usual manner, but may not be counted toward any degree currently offered at Georgia Tech.

Interested persons should consult officials of the appropriate colleges and departments for details.

POLICIES AND REGULATIONS

Though final authority rests with the Academic Senate, the graduate committee with the approval of the Senate is responsible for establishing academic policy for the graduate program. This committee reserves the right to change requirements for degrees as may be appropriate. Students who are enrolled at the time such changes are made shall have the privilege of following either the regulations stated in the catalog effective the quarter in which they enrolled, or the regulations in the catalog which records the change.

The Institute-wide policies and regulations that govern the graduate program are recorded in this catalog. The several schools may make additional rules concerning programs and the pursuit of degrees in their schools, but these rules may not contradict Institute policies and regulations.

Graduate Student Work Loads

The minimum hours for which a student may be enrolled is three. The maximum hours for which a student may be enrolled is 18. A full-time student must be enrolled for at least 12 hours. The special regulations concerning the number of hours of enrollment for students who hold assistantships or fellowships or who work on a full- or part-time basis are on file in each school and in the graduate office. The average student is expected to devote four hours of effective work per week for each credit hour scheduled at the graduate level.

Staff Members

No staff member beyond the rank of instructor will be permitted to work for a master's degree in the school in which he or she serves.

No new staff member with the rank of assistant professor will be permitted to work for a doctoral degree in the school in which he or she serves.

ADMISSIONS INFORMATION

All correspondence concerning admission to graduate study should be directed to the appropriate school. Necessary admission forms may be obtained from the appropriate school or from the Office of Graduate Studies and Research. These forms, together with letters of recommendation and official transcripts of previous academic work should be mailed to the several offices of the Institute as specified in the instructions given on the application blank and should be on file at the Institute by August 1 for fall quarter, December 1 for winter quarter, March 1 for spring quarter, and June 1 for summer quarter. No application fee is required. In addition, a graduate studies brochure and a financial aid booklet designed specifically for graduate student needs may be obtained by writing to:

Office of Graduate Studies and Research
 Georgia Tech
 Atlanta, Georgia 30332

Graduate Record Examinations

Applicants may be required by the director of their school to submit results of the Aptitude and Advanced tests of the Graduate Record Examinations (GRE).

Students applying to the Schools of Biology, Geophysical Sciences, Psychology, Textiles, Management (economics only), Industrial and Systems Engineering (operations research program only) and Information and Computer Science (Ph.D. applicants only) are required to submit GRE scores. Applicants to the Schools of Biology, Chemistry and Mathematics must

take the Aptitude and Advanced tests of the GRE. All scores should be sent directly to the school and not to the graduate office. Students applying to the College of Management are required to supply General Management Aptitude Test (GMAT) scores and should have these scores sent directly to the dean of the College of Management.

Information as to time and location at which these tests are given can be obtained by writing to Graduate Record Examinations, Educational Testing Service, Box 955, Princeton, N.J., 08540. Inquiries from students in western states should be addressed to 1947 Center Street, Berkeley, California 94704.

Information on the GMAT test may be obtained by writing the Educational Testing Service, Box 966, Princeton, N.J., 08540.

Types of Standing

Full graduate standing will be accorded those applicants holding a bachelor's degree from an approved institution whose previous work has been of a nature and quality sufficient to offer reasonable assurance of immediate success in advanced study.

Conditional graduate standing will be granted to applicants holding a bachelor's degree from an approved institution whose previous work, because of deficiencies either in content or quality, must be supplemented by additional work or demonstrated ability to be performed at a specified level.

Admission as a special graduate student may be granted to students who do not wish to qualify for an advanced degree at Georgia Tech, but who can demonstrate that the pursuance of certain advanced work will be of real benefit.

Students working toward a second bachelor's degree will be registered in the undergraduate school.

Students who are graduate students in good standing at another university may be admitted as transient graduate students after filing an application and verification of good standing status. The work undertaken will not be applicable toward a Georgia Tech degree.

In addition to full, conditional and special graduate standing, graduate students will be assigned certain levels of academic standing depending upon their grade point averages—good standing, warning, probation or drop. See "Student Rules and Regulations" for specific information.

Readmission

Students who interrupt the continuity of their graduate programs by not registering for one quarter (summer quarter excepted) must seek readmission by filing with the registrar a completed request for readmission form by August 1 for fall quarter, December 1 for winter quarter, March 1 for spring quarter and June 1 for summer quarter. Request forms are available from the registrar's office.

Reactivation of Application

Students who have been admitted for graduate study at Tech but who do not enter in the quarter for which they applied and subsequently wish to be considered for a later quarter must reactivate their application for the new quarter. Since files are kept by the graduate office and the registrar's office for only one year on "never entered" students, these students will have to supply a whole new set of application materials if they delay more than one year in the reactivation request. To reactivate an application the student must request reactivation in writing to the registrar by August 1, December 1, March 1 or June 1 for the fall, winter, spring or summer quarters, respectively.

Undergraduate Students

Well qualified undergraduate students with at least a 2.7 cumulative GPA may schedule graduate courses in their senior year. The student must obtain permission from his or her adviser and the director of the school in which the course is offered.

Credit toward the master's degree for work by undergraduates will be allowed only under the following conditions.

1. The student must have been in residence at the Georgia Institute of Technol-

ogy for at least two quarters before registering for the course for which he or she desires graduate credit.

2. Credit for the course must not have been applied toward an undergraduate degree.

3. The student must petition the Graduate Committee of the Academic Senate to request such credit.

Registration

Registration dates will be found on page 30 of this catalog. New graduate students must report first to their school at 8 a.m. on registration day, where further instructions regarding registration procedures will be made available.

Each new graduate student must plan for an interview with the director of his or her school of specialty during the week before registration to prepare the proposed program of graduate study.

Orientation for new graduate students is conducted in the fall quarter just before registration.

TOEFL for International Students

Test of English as a Foreign Language (TOEFL) is required of all international students coming from countries in which English is not the native language. The student should arrange to have the Educational Testing Service send test results to the registrar's office as early as possible, for this information constitutes a part of the material reviewed for admission to graduate study at Georgia Tech. At present, the minimum score acceptable for admission into the graduate program is 550.

Students who wish to take TOEFL in any country except Hong Kong, India, Nepal or Taiwan should obtain the *TOEFL Bulletin of Information for Candidates, International Edition*. Copies of this *Bulletin* and the registration form may be obtained in a number of cities outside of the United States. They often are available at American embassies and consulates, offices of the United States Information Service (USIS), United States educational commissions and foundations abroad and binational centers. In addition, several private organizations dis-

tribute *TOEFL Bulletins*. Among them are 1. the Institute of International Education (IIE) in Nairobi, Kenya; Paris, France; and Lima, Peru; 2. the African-American Institute (AAI) in Dar es Salaam, Tanzania; and Lagos, Nigeria; 3. the American Mid-east Educational and Training Services (AMIDEAST) in Amman, Jordan; Beirut, Lebanon; Tangier, Morocco; and Cairo, Egypt; and 4. the American-Korean Foundation in Seoul, Korea.

Students who cannot obtain locally a *TOEFL Bulletin of Information for Candidates, International Edition* and registration form should write for them well in advance to: Test of English as a Foreign Language, Box 899, Princeton, New Jersey, U.S.A. 08540.

THE MASTER'S DEGREE

Prerequisites

Applicants are expected to hold a bachelor's degree from a recognized institution and to have graduated in the upper half of their class. Students must show evidence of preparation in their chosen field sufficient to ensure profitable graduate study.

Matriculation Requirements

A student is matriculated for a graduate degree upon admission to graduate study with either full or conditional standing. The student must be classified as having full graduate status in order to graduate with the M.S. degree.

Students who have matriculated for the master's degree are required to maintain continuous matriculation if the original requirements for the degree remain unchanged. If continuous matriculation is not maintained, the student's credentials are subject to re-evaluation and additional requirements for the degree may be imposed.

Continuous matriculation will be maintained by the student if he or she is officially registered for at least one quarter per calendar year during the period of six years following original admission.

If a student has completed all course work and is planning to submit a thesis in partial fulfillment of the requirements for a master's degree, the student should register for research hours consistent with a realistic appraisal of the amount of work yet to be done on the thesis and the amount of faculty involvement required. *The student is not entitled to receive thesis guidance during any quarter in which he or she is not registered.*

Twelve credit hours per quarter, excluding audit hours, will be considered the minimum for which full residence credit may be granted. Lighter schedules will be prorated on this basis in computing residence gained.

The Institute has no residency requirement for master's level degrees.

Academic Requirements

The minimum number of approved credit hours required for the master's degree shall be 50, credited as follows.

With thesis:

Minimum course credit hours in major field*	18
Minimum course credit hours at 6000 to 9000 level	18
Total course credit hours for degree	36
Research hours	17
Total credit hours	50

Without thesis:**

Minimum course credit hours in major field	27
Minimum course credit hours at 6000 to 9000 level	35
Total credit hours	50

*The term "major field" as used in these regulations indicates a basic field of knowledge rather than a department of specialization.

** Must have approval of school director.

A student must earn a graduate grade average of at least 2.7 and satisfy other requirements of his or her school before being certified for a master's degree. Grade points are given for all courses in which grades are reported. They are com-

puted as follows: for each credit received in a course, 4 grade points are granted if the grade is A, 3 if B, 2 if C, 1 if D and 0 if F. The graduate average includes the grades on all courses scheduled by the student after being admitted to graduate study plus the grades on all courses listed on the student's approved program of study which have been earned at Georgia Tech prior to the student's admission to graduate study. Other than thesis hours, only six hours may be taken "pass-fail" (see p. 38).

Undergraduate courses required for graduation in the discipline (designated degree) or discipline-of-origin (undesignated degree) at Georgia Tech may not be applied toward a master's degree. No graduate credit will be given for any course not approved by the school, graduate committee and academic senate.

The student, in conference with the faculty adviser, should prepare a program of study for the master's degree as a guide in planning his or her academic schedule. According to the requirements of the school in which the student is enrolled, the student may be required to submit this program to the director of the school. The student must submit an approved program of study form (attached to his petition to graduate) to the Registrar's office.

Admission to Candidacy for the Master's Degree

Admission to graduate standing does not constitute acceptance as a candidate for an advanced degree. To obtain consideration for this privilege the student must have shown evidence of ability to pursue a program of graduate study and research. A mere accumulation of credits is not sufficient. A petition for a degree, with an approved program of study attached (forms available in the Registrar's office), is to be submitted to the Registrar during the quarter prior to the final quarter in which the work for the degree is to be completed. To receive favorable action on this petition, the applicant must ordinarily have met the following requirements.

1. The student must show that he or she will have satisfactorily completed course

requirements for the master's degree (see Academic Requirements).

2. The student must have completed, or be scheduled to complete during the quarter, any required noncredit prerequisite work outlined at the time of his or her matriculation.

3. The student must have an overall grade point average of at least 2.7 and satisfy the requirements of his or her school.

4. The student must have completed satisfactorily any language requirement imposed.

5. The student must have passed any qualifying or comprehensive examinations required by the department in which he or she is registered.

6. The student must have filed with the Office of Graduate Studies and Research an approved thesis topic and have made satisfactory progress on his or her thesis if it is a part of his or her program.

Requirements for Award of the Degree

The graduate committee normally recommends to the Academic Senate the awarding of the master's degree to any candidate who:

1. has an overall grade point average of at least 2.7 and has satisfied the requirements of his or her school,

2. receives final acceptance of his or her thesis from the office and deposits three unbound copies with the library,

3. supplies the office with a publishable abstract of his or her thesis, up to 300 words, the accuracy of which has been certified by the thesis adviser,

4. presents an approved program of study (complete within a period of not more than six consecutive calendar years) to the Registrar in accordance with the deadline set forth in the Institute calendar,

5. passes any general examinations, oral or written, required by his or her school and

6. is, at the time, a registered student.

Language Requirement

A reading knowledge of one appropriate foreign language may be required at the option of the school in which the student is registered. Foreign students will be expected to show adequate mastery of English.

Transfer of Credit

The rules relative to and the process for obtaining transfer of credit for graduate level courses are as follows.

1. Transfer credit (up to nine hours) can be obtained for graduate level courses taken elsewhere in the United States if they have not been used for another degree. A current transcript is required for this evaluation.

2. Joint-enrollment students may be allowed to receive graduate credit for up to one-third of the hours required for the degree for graduate courses taken at Emory University or Georgia State University, (1) provided such courses are not offered at Georgia Tech, (2) are approved in writing in advance by the student's adviser and school director and (3) are passed with a grade of C or better. "Advance approval" is satisfied when the courses appear on the student's proposed program of study.

3. No transfer credit will be granted from universities outside the United States and Canada; however, international students can obtain credit for courses previously taken, and not used for another degree by filling out an "Examination for Advanced Standing Authorization Request Form," paying the appropriate fee at the cashier's office, and passing the examination for advanced standing. Each school or department which normally teaches the equivalent course will administer such examinations, if warranted.

4. The process for obtaining transfer of credit:

a. The student must confer with his or her graduate adviser to ascertain whether the courses to be transferred are a logical part of the student's graduate program. The courses would typically be those appearing on the approved program of studies form for the master's program student. A doctoral program student would normally not be seeking transfer of credit.

b. If the courses are appropriate, the student should take a copy of the current transcript that shows the courses, appropriate descriptive materials, such as catalog description and textbook used, to the school on campus that teaches or comes close to teaching the courses. These courses must be evaluated by a member of

the appropriate faculty who will indicate the number of credit hours and the Georgia Tech counterpart. The professor should prepare a transfer credit form and if he or she is not the school director, the school director should cosign it. The transfer credit form should then be sent directly to the Registrar, with a copy of the student's *Approved Program of Study* attached.

c. If the student wishes to transfer more than nine hours, he or she must file a petition with the graduate committee including statements of possible justification for the granting of such a petition. On this petition there must be a recommended action by the student's school director. Transfer credit forms must accompany such a petition to serve as documentation.

The Master's Thesis

A master's thesis is a requirement for the master's degree except in those cases where the director of the school in which a student is registered may consider additional course work of more importance in meeting the student's approved objective.

Students who meet the requirements for the master's degree by completing a combination of course work and thesis are required to register for a minimum of 17 hours of credit in thesis. (See section on matriculation requirements.)

A candidate whose program includes a thesis must present a treatise in which are set forth in clear, articulate form the results of an investigation directed by a member of the faculty of the Institute. The purpose of the thesis is to further the educational development of the student by requiring him or her to plan, conduct and report an organized and systematic study of importance.

The Manual for Graduate Theses, available from the graduate office, specifies the requirements for the thesis.

THE DOCTORAL DEGREE

The degree of Doctor of Philosophy is basically a research degree awarded in recognition of demonstrated proficiency and high

achievement in research. After adequate preparation the candidate must complete a searching and authoritative investigation of a special area in the field of his or her choice, culminating in a written dissertation covering that investigation. The dissertation must be either an addition to the fundamental knowledge of the field, or a new and better interpretation of facts already known. It must demonstrate that the candidate possesses powers of original thought, talent for research and ability to organize and present findings.

Matriculation Requirements

Ordinarily a student will be admitted for study at the doctoral level only if he or she has graduated in the upper quarter of the class. This requirement may be modified for those who have shown unusual promise in their work toward a master's degree.

Except for this restriction, the matriculation requirements are identical to those outlined for the master's degree.

At least three full-time quarters must be spent in residence at the Georgia Institute of Technology. Ordinarily research for the doctoral dissertation must be carried out while in residence on the campus. However, when the candidate has met the residence requirements, he or she may be permitted under special circumstances to pursue further work in absentia if done under the direction of a faculty member and approved by the director of the school concerned.

Admission to Candidacy

Admission of a student to candidacy for the doctorate is based primarily upon the passing of certain comprehensive examinations. These examinations have as their objective the testing of the student's knowledge of the general field in which the student is to receive his or her degree, as well as the specialized portion of this field in which his or her research is being carried out. In general, the student will find it advisable to complete at least five quarters of course work beyond the B.S. degree before taking these examinations.

The comprehensive examination will

normally be given at least once a year, in the fall or in the spring. The examinations are the responsibility of the school which will grant the degree. The student shall be informed of the scope of the examinations.

Students will be guided in the planning of a program of study and in the preparation of these examinations by a guidance committee appointed by the director of the school. The duties of the committee shall include evaluation of the background and interests of each entering student, aiding the student in planning course work and consultation with the student from time to time for purposes of evaluating and aiding his or her progress.

The student will be expected to take examinations in all courses in which he or she is regularly enrolled. The student's grades in these courses will be reported in the usual manner to the Registrar.

The student must satisfy the following requirements prior to admission to candidacy for the degree.

1. The comprehensive examinations must have been passed.
2. The student must have filed with the director of his or her school and the Office of Graduate Studies a formal statement naming the student's thesis adviser and setting forth the research topic, the purpose of the investigation and the steps by which the student proposes to conduct it.

Upon satisfactory completion of these requirements, with approval of the thesis topic, the applicant may be formally admitted to candidacy for the degree.

A petition for a degree is to be submitted to the Registrar during the quarter prior to the final quarter in which the work for the degree is to be completed. Petition forms are available in the registrar's office.

The requirements for the degree must be completed within five years from the end of the quarter in which the candidate passes the comprehensive (qualifying) examinations.

Major and Minor Fields of Study

While there are no fixed course requirements for the doctorate, the student will be expected to pursue both a major and a

minor field of study. The student's program will usually require two or more years of course work beyond undergraduate study.

In addition to an adequate knowledge of the major field in which research is to be carried out, the student will be required to demonstrate a mastery of some other, smaller body of knowledge within or, preferably, outside the student's school. This area of study is referred to as a minor field. The purpose of the minor is to encourage a wider interest on the part of the student and to provide a broader basis for the evaluation of his or her capabilities.

The minor will normally consist of at least 15 quarter hours of work in related courses, chosen by the student in consultation with his or her guidance committee. The minor must be approved by the Office of Graduate Studies. After the minor is satisfactorily completed, this fact should be transmitted to the graduate office accompanied by the grades in the courses for final approval and recording.

Completion of the minor is not a prerequisite for admission to candidacy, but it must be approved and completed before clearance for the degree.

Language Requirements

Every doctoral candidate is required to have had exposure to some cultural and functional aspects of foreign languages before being granted the degree. The student may satisfy this requirement by any one of the following options:

1. The student may pass two years of course work in foreign language at the college level with an average grade of C or better. This may include one year each in two different languages or two years in one language. Every two years of foreign language course work in a particular language in secondary school will be considered equivalent to one year of college course work.

2. The student may enroll in one of the following sequences of courses and earn an average grade of C or better:

- a. French 4075-6-7
Intensive Readings in French
- b. German 4075-6-7
Intensive Readings in German

- c. Russian 4075-6-7
Intensive Readings in Russian
- d. Spanish 4075-6-7
Intensive Readings in Spanish
- e. Linguistics 4075-6-7
Languages for Science and Technology

3. The student may petition for and pass a written equivalency test in one foreign language administered by the Department of Modern Languages in lieu of formal course work. The proficiency level expected is comparable to that of a student just completing the present second-year language course in the Department of Modern Languages with a grade of C or better.

4. The student may present evidence or other experiences that clearly demonstrate an exposure to cultural and functional aspects of foreign language equivalent to the above, such as having been reared and educated in a mother tongue other than English.

It shall be the authority of the Department of Modern Languages to evaluate and certify to the graduate office the satisfactory completion of the above foreign language requirements for each candidate. If the student wishes to satisfy the language requirement using alternative one or four, he or she must supply complete official records and English translations of such records when appropriate.

Additional requirements of proficiency in reading or translating scientific literature in one or more foreign languages may be imposed by an individual school at its discretion.

The Dissertation

Prior to the student's admission to candidacy the candidate will present for the approval of the director of his or her school and the Office of Graduate Studies a formal statement naming the student's dissertation adviser and setting forth the topic that has been selected for investigation, the objectives the student hopes to gain and the steps by which the student proposes to gain them. The dissertation topic

must give promise of being either a genuine addition to the fundamental knowledge of the field or a new and better interpretation of facts already known.

Instructions concerning the dissertation are obtainable from the Office of Graduate Studies. All dissertations are microfilmed and deposited with the University Microfilms Service. A charge of \$30 must be paid by the student to the Institute for this service.

The Doctoral Examination

If the Dissertation Advisory Committee finds the dissertation satisfactory, the candidate will be called for an oral examination on the subject matter of the thesis and the field in which it lies. The examination will be made by an examining committee approved by the Office of Graduate Studies. The student must be registered during the quarter in which the final examination is given and in the quarter in which he or she graduates.

If both the dissertation and the examination are satisfactory and the requirements of residence languages and the minor field have been complied with, the candidate will be certified as qualified to receive the degree of Doctor of Philosophy.

In the case of a failure on the final oral examination, on the recommendation of the examining committee one additional examination will be permitted. In case of failure no report of the result of the examination will be sent to the registrar, but a record will be kept in the Office of Graduate Studies.

Additional requirements for the doctorate may be added by the schools at their discretion.

FINANCIAL INFORMATION

Costs

The following schedule of matriculation, tuition, student activity and other fees is effective for the 1980-81 academic session.

	Matriculation	Tuition	Transportation	Student Activity	Medical	Total Fees Per Quarter	Total Fees Per Academic Year
Residents of Georgia	\$236		\$3.50	\$24	\$28	\$291.50	\$874.50
Nonresidents of Georgia	\$236	\$550	\$3.50	\$24	\$28	\$841.50	\$2524.50

An extra fee may be charged in special courses.

Graduate students carrying a full academic load (12 credit hours or more per quarter) will be charged the full amount of all fees as shown above.

Part-time students (those carrying less than 12 credit hours per quarter) who are legal residents of Georgia will be charged \$20 per credit hour in satisfaction of the matriculation fee and \$52 for the student activity and medical fees unless the student is carrying less than six credit hours. For these students only the matriculation fee is charged. All other graduate students will have an additional tuition fee of \$46 per credit hour. *The minimum number of hours a student may enroll for is three.* All students must pay the \$3.50 transportation fee. A charge for one quarter hour is made for registration for a zero credit hour seminar if the student is registering for less than 12 credit hours.

Graduate students who have completed the residence requirements for the degree may register for research only at the rate of \$20 per designated equivalent credit hour. Hours for which the student is registered shall be consistent with a realistic appraisal of the amount of work yet to be done on the thesis or dissertation and the amount of faculty involvement required. Such registration carries no residence credit and must be approved by the graduate office.

Note: conditions may arise beyond the control of the Georgia Institute of Technology which will cause the rate for tuition, fees, board and room to be changed during the next year without notice.

Other Fees

Each person receiving a diploma must pay the appropriate diploma fee before graduating. A candidate for the doctoral degree must pay a charge of \$30 for microfilming his or her dissertation and depositing it with the University Microfilms Service.

The cost of binding the three library copies of a student's thesis or dissertation is borne by the Institute.

A late registration fee is charged after regular registration. If a student has not paid all fees by the end of the first week of the quarter, his or her registration will be cancelled.

Refund of Fees

The Institute has an established set of rules governing the refund of fees to students who must drop out of school or lower their academic load to 12 credit hours or below (see page 43).

Obligations of Students

An individual is not officially enrolled at Georgia Tech until all transportation, tuition, matriculation, student activity and medical fees for the current quarter are paid. Once enrolled, every student is obli-

gated to remit, return or submit all other financial obligations that may become due, as well as property or records of the Institute, within the time prescribed by the Institute. Failure to fulfill any such obligation will result in denial of registration privileges for subsequent quarter(s). Such denial of registration privileges is in addition to and apart from any disciplinary measures which may be taken pursuant to the Student Conduct Code, pg. 314 ("Student Rules and Regulations").

Financial Assistance

The Institute offers financial aid from a variety of sources to assist students with the pursuit and completion of their degree as rapidly as circumstances permit.

Inquiries for financial aid should be addressed to the director of the school in which the student plans to study.

President's Fellowships

Each year the Institute awards fellowships to matriculants with outstanding academic records and high research potential. Approximately three-fourths of these awards are made to applicants who expect to pursue the doctoral degree. The remainder are awarded to master's degree candidates. The award is \$5,000 plus waiver of all tuition and fees for four quarters.

Graduate Research Fellowships

These fellowships are designed specifically for the prospective student with outstanding academic records and high research potential who wishes to combine research on a significant up-to-date project (in a particular school, research center or at the Engineering Experiment Station) with normal academic progress. Students may enter the program at any level—beginning, intermediate or final.

Graduate Research Assistantships

These awards are ordinarily offered students on a one-third or half-time basis. However, awards of a greater or lesser amount may be offered according to the needs of the respective school departments and centers, or divisions of the Engineering Experiment Station.

Graduate Teaching Assistantships

These awards are ordinarily offered on a one-third or half-time basis. However, awards of a greater or lesser amount may be offered according to the needs of the respective schools and departments.

Federal Fellowships and Traineeships

The Institute awards a number of fellowships and traineeships through participation in programs sponsored by agencies of the federal government.

In addition, traineeships associated with specific training programs are available as follows: water resources planning and management through the Environmental Resources Center, solid waste training program through the School of Civil Engineering, radiation health specialist training program through the School of Nuclear Engineering, environmental health through the School of Civil Engineering, air quality control through the School of Chemical Engineering and mineral and mining through the School of Ceramic Engineering.

Tuition Waivers

Nonresident graduate students who hold assistantships or work for the Institute in a professional capacity on at least a one-third-time basis may register on payment of resident fees. In addition, there are available a limited number of tuition waivers for award to qualified out-of-state students upon recommendation of the school director. Preference will be given to those students taking 12 hours or more of courses for credit and having an outstanding academic record. Full-time students sponsored by WSF, AFGRAD, LASPAU and certain IIE students may carry top priority if Georgia Tech has given an institutional commitment to the group or agency. Since there are usually many more people recommended than the 40 waivers will support, grade point averages will be used in determining the final allocation of awards by the graduate office.

Local Industry Work-Study Programs

Many industries located in and around Atlanta offer opportunities to pursue graduate degrees as an integral part of their employee training programs. In such a plan,

the student may work and study on a reduced work week schedule that is compatible with school, student and company requirements. Academic fees, costs of texts and a supply allowance may be paid by the company.

Graduate Employment

Appointments of graduate students in the Engineering Experiment Station may be made on the recommendations of the director of the school in which the student is registered, the director of the experiment station and the graduate office. Graduate students are appointed as graduate research assistants. They may participate in investigations which are conducted in the experiment station on the subject of a thesis, provided the subject is acceptable to the school director concerned and the degree of responsibility borne by the student is considered sufficient.

Veterans Program

Veterans may be eligible to receive educational assistance through the Veterans Administration while enrolled and pursuing an approved program of education or training if they were discharged after January 31, 1955, under conditions other than dishonorable from a continuous period of active duty of 181 days or more. If the period was less than 181 days, a veteran may be eligible if the discharge was for service connected disability.

The VA provides educational assistance to children of veterans who died or are permanently and totally disabled as the result of service connected disability incurred or aggravated during active service in the Armed Forces, or children of individuals on active duty who are listed for more than 90 days as missing in action, captured by a hostile force or forcibly interned by a foreign government or power.

The Financial Aid Office at Georgia Tech serves as the veterans affairs center on campus and provides enrollment certification to the Veterans Administration for eligible students. New students and enrolled students wishing to be recertified should make application to the Financial Aid Office at least six weeks prior to the planned quarter of enrollment if the first benefit

check is desired for use in registration.

Any questions or comments may be directed to the Financial Aid Office at Georgia Tech.

Sponsored Assistantships

The School of Health Systems awards assistantships to a number of graduate students for participation in the community outreach program of the Health Systems Research Center. Sponsored funding is provided by cooperating health care institutions and health service organizations in the metropolitan Atlanta area. These appointments are normally on a one-third-time basis and provide compensation and tuition waivers comparable to those for research and teaching assistantships.

Currently participating in this program are Atlanta Heart and Lung Clinic, Crawford W. Long Memorial Hospital, Fagin Advisory Services, Georgia Baptist Hospital, Health Care (HMO), Hospital Investors, Joint Board of Family Practice, MEDICUS and Piedmont Hospital.

Sponsored Fellowships

The Institute has a number of fellowships that are contributed by various industrial organizations, foundations and trust funds for the support of outstanding graduate students. These fellowships assist students in pursuing their studies and research full time. The name given each fellowship listed below indicates the donor or person(s) memorialized by the fellowship.

Allied Chemical Foundation Fellowship
A \$4,500 fellowship to a candidate for the Ph.D. in textile science and engineering.

Domenica Rea D'Onofrio Fellowship
A fellowship in all schools of instruction—recipient must be from Italy. Stipend of \$3,500.

Edward Orton, Jr. Foundation Fellowship
A fellowship in ceramic engineering carrying a stipend of \$1,800 for 12 months study, plus \$200 for equipment and supplies.

E. I. du Pont de Nemours & Company, Inc.
A grant of \$10,000 to be allocated to each of four schools, chemical engineering,

chemistry, electrical engineering and mechanical engineering. It is to be used to enhance or maintain the strength of their instruction in science and engineering.

Eno Foundation of Transportation Fellowship

A \$7,000 fellowship to the School of Civil Engineering to cover tuition, living expenses and other necessary costs for the 1980-81 academic year.

Ford Foundation Fellowship

Fellowship and loan for doctoral studies in engineering. These awards are a combination of fellowship and teaching research assistantships valued at up to \$3,000 plus tuition and fees and may be awarded for a calendar year including the usual vacation periods. Also, loans based on need up to \$3,000 annually will be available to well qualified graduate students motivated toward academic careers. The loans will be cancelled at a minimum rate of \$1,000 per year for each full-time year of service in an academic career in the United States and Canada.

Foundation in Refractories Education—F.I.R.E.

A \$5,000 fellowship in ceramic engineering. This is for students whose interests are in the refractory materials area.

G. B. Espy Faculty Bioengineering Fellowship

A fellowship to aid Georgia Tech professors in moving into the medical profession as bioengineers. To be eligible a person must be currently a member of the Georgia Tech staff, possess either a Ph.D. or Sc.D in chemical engineering, electrical engineering, mechanical engineering or nuclear engineering and at the time of application be accepted by a medical school as a full-time student in a program of study leading to the M.D.

Graduate and Professional Opportunities Program Fellowships

These fellowships, granted to the Institute by the Office of Education, DHEW, are available to women and minorities who wish to pursue a graduate degree program in architecture, engineering, information

and computer science or geophysical sciences. The awards are \$3,900 each plus all tuition and fees for four quarters of study and are renewable for up to four years.

Gulf Oil Foundation Graduate Fellowship

A \$6,000 fellowship to the School of Chemical Engineering. Stipend not less than \$3,000 plus tuition and fees. Balance to be used as an unrestricted grant to the school not to exceed \$1,000.

Howard Pyle Safety Research Fellowship

A fellowship for advanced study leading to a doctorate in a safety-related discipline with an emphasis on research. It has a stipend of \$2,500 with a total allowance of \$450 for dependent children plus tuition and fees (up to \$4,000).

IBM Fellowship

One fellowship of \$3,600 for 12 months. Awarded to doctoral students only. Selection is based on socioeconomic criteria and promise of professional accomplishment.

Mary White Staton

A fellowship in all schools of instruction—recipient must be from Colombia, South America. Stipend of \$2,000.

National Consortium for Graduate Degrees for Minorities in Engineering Fellowship

Candidates for participation in this program are selected from minorities (black Americans, Puerto Ricans, American Indians and Chicanos). At the time of application the student should be enrolled in the junior year of undergraduate study in one of the engineering disciplines. In addition to the graduate stipend, this program provides an opportunity for summer work experience in one of several off-campus research laboratories. An applicant's record must indicate the ability to pursue graduate studies in engineering. Some students who are presently in their senior year of undergraduate study will be accepted into the program. For further information write to the Office of Graduate Studies, Georgia Institute of Technology, Atlanta, Georgia 30332.

Paul R. Yopp Fellowship

A fellowship in mechanical engineering to

an outstanding graduate student covering a stipend, tuition and fees.

Robert & Company Associates Fellowship
A fellowship in architecture. \$1,200 stipend. Recipient must be a native of Georgia.

Robert & Company Fellowship

A fellowship to be used in civil, electrical or mechanical engineering. \$1,200 stipend. Recipient must be a native of Georgia.

Sandoz Foundation Fellowship

A \$5,000 fellowship in textile chemistry. These funds are for stipend, tuition and fees, equipment and faculty supervision.

Schlumberger

Two fellowships in electrical engineering. Tuition and fees, plus \$3,000 stipend. Total grant \$5,500.

Tennessee Eastman Fellowship

A \$4,000 fellowship to the School of Chemical Engineering. Stipend not less than \$2,500 per calendar year or \$3,000 if there are dependents, plus tuition and fees. Balance to be used as an unrestricted grant in the school.

Texaco Fellowship in Metallurgical Engineering

A fellowship to encourage graduate studies in metallurgical engineering. Awarded at the discretion of the Department of Metallurgy in the School of Chemical Engineering. Stipend is \$3,000 plus tuition and fees for a 12-month period.

Union Camp Fellowship

A \$5,000 fellowship in chemistry and chemical engineering. Tuition and fees, plus a minimum of \$250 per month to the student for a period of at least nine months, the remaining money to be used for department needs.

United States Steel Foundation Loan Fund
A short term loan fund designated to assist graduate students in engineering, physics, chemistry and mathematics. Administered by the Financial Aid Office.

Whirlpool Corporation

Three graduate fellowships in engineering (electrical, mechanical and textile). Stipend, plus tuition and fees.

CURRICULA AND DEGREES

The specific degree requirements for each curriculum at both the undergraduate and graduate levels are listed alphabetically by colleges. Course descriptions are listed alphabetically by schools and departments of instruction in the section "Courses of Instruction."

Course numbers below 3000 are lower division (freshman and sophomore) courses. Those numbered 3000-4999 are designated as upper division (junior and senior) courses. They are open to students of the lower and upper divisions with the proper prerequisites and to graduate students on approval of the individual student's major. Courses designed for graduate students are numbered 5000 and above; the methods of presentation and quality of work expected make them generally unsuited to undergraduate participation. An upper-division undergraduate student is therefore permitted to enroll in a graduate level course only after consultation with and approval of his or her major school and the dean of the graduate division.

Figures entered beside the course number and title of each course signify the number of class hours per week, the number of laboratory hours per week and the quarters credit for the completed course, in that order. Thus, the entry 4-3-5 in Chem. 1101 means that the course meets for four lecture hours per week, has three hours of laboratory work per week and is evaluated at five quarter hours credit upon completion of the quarter's work.

COLLEGE OF ARCHITECTURE

**Established in 1975,
school in 1948, department in 1908**

Dean—William L. Fash; *Assistant Dean for Instruction*—Joseph N. Smith; *Assistant Dean for Research*—John A. Templer; *Professors*—Arthur F. Beckum, Jr., Clifford R. Bragdon, Arnall T. Connell, Dale A. Durfee, Geoffrey G. Eichholz (part-time), William L. Fash, John C. Gould, John A. Kelly, Malcolm G. Little, Jr., Robert J. Nichols, Elliott A. Pavlos, George H. Ramsey, Roger F. Rupnow, Joseph N. Smith, John A. Templer, Richard Wilson; *Visiting Professors in a typical year*—Pershing Wong (fall), Sergio Lenci (spring), Carl J. Tschappat (part-time); *Associate Professors*—James M. Akridge, Stanley C. Bailey (part-time), Alan H. Balfour, Neill W. Connah, Robert M. Craig, M. David Egan (part-time), C. Malcolm Gailey, Rufus R. Greene, Rufus R. Hughes II, Lewis F. Lanter, Terrence L. Love (part-time), Richard J. L. Martin, Eldon S. Miller, C. Lee Payne, H. Randall Roark (part-time), Clyde D. Robbins (part-time), Robert T. Segrest, C. Virgil Smith (part-time), John E. Williams; *Assistant Professors*—Douglas C. Allen, C. Cris Benton, Robert A. Bridges, Richard Dagenhart, Thomas N. Debo, Lionel D. Gillespie (part-time), Edward L. Keating, Robert Merz, Cheryl E. Morgan, Thomas E. Papa-george, Catherine B. Ross, William H. Russell, Albert H. Smith, Jay M. Stein, Jean D. Wineman, Craig M. Zimring; *Instructor*—Jessica P. McLean (part-time); *Lecturers*—John C. Archea, Anthony M. Ames (part-

time), James L. Gebhardt (part-time), Marvin Housworth (part-time), Robert C. Maxwell (part-time), James W. Mount (part-time), Joseph de Casseres Reshower (part-time), Frank H. Stephens (part-time), Richard L. Taylor (part-time), Joan Templer, Morris Ward (part-time), Ronald W. Wilson (part-time); *Administrative Specialist*—Mack A. Lewis.

General Information

The College of Architecture, established in 1908 as the Department of Architecture, became a school in April, 1948 with the change in name of the institution to the Georgia Institute of Technology. It was elevated to the status of a college on July 1, 1975.

The original four-year curriculum led to the degree Bachelor of Science in Architecture, but in 1934 this was extended to a five-year program awarding the degree Bachelor of Architecture, which was offered as a first professional degree until 1972.

The four-year degrees, Bachelor of Science in Building Construction and Bachelor of Science in Industrial Design were established in 1958 following a period during which the curricula in these disciplines functioned as options under architecture. Recent changes in the content of all curricula take precedence over the listings in earlier catalogs.

The degrees Master of Architecture and Master of City Planning were initiated in 1952 and a joint degree program with the simultaneous award of both degrees has been in operation since 1969. Two-year joint degree programs between city planning and civil engineering (transportation), city planning and urban design, and city planning and environmental design (landscape architecture) at the University of Georgia are currently available.

The original aim and first objective of the college has been to prepare students for the profession of architecture. The scope of man's concern with the environment is of such breadth in current practice, however, that architects and planners not only must exhibit strength in the traditional role of

building and space design, but also must reemphasize related interests in the social sciences and psychology, structural and mechanical systems, management of construction and field processes and economic and feasibility programming. Graduates with such grounding contribute effectively to teams that create and control the man-made environment at every scale, from the production of the smallest utilitarian object to community, city and regional planning. It is to this end that, over the years, the College of Architecture has embraced as many disciplines in design and planning as possible, not only to educate its students in specialized environmental fields, but also to liberalize and expand the education through their interaction.

Architecture

The undergraduate curriculum in architecture prepares the student through basic professional studies and general education to receive the degree Bachelor of Science (undesignated) at the end of four years. It should be noted that this is not a professional degree in architecture and will not be recognized as such by the National Architectural Accrediting Board and the National Council of Architectural Registration Boards; professional degree accreditation applies only to the degree Master of Architecture, awarded after two years of graduate study.

For architecture majors, averages in architectural design will be checked at the end of each year-group of three courses (Arch. 1001-2-3, etc.). A student will not be permitted to enter a more advanced group until his or her record in the previous group equals 2.0 or better. All work executed in the college becomes the property of the college and will be retained or returned at the discretion of the faculty. The faculty reserves the right to refuse for credit any project executed outside the precincts of the college, or otherwise executed without proper coordination with the instructor.

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Arch. 1001-2-3			
Design Fundamentals	1-12-5	1-12-5	1-12-5
Arch. 1201-2-3			
Architectural History	3-0-3	3-0-3	3-0-3
Math. 1307-8-9			
Mathematics	5-0-5	5-0-5	5-0-5
Electives²			
Physical Education	0-4-1	0-4-1	0-4-1
Electives¹	3-0-3	3-0-3	3-0-3
Totals	12-16-17	12-16-17	12-16-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Arch. 2001-2-3			
Architectural Design	1-12-5	1-12-5	1-12-5
Arch. 2301-2-3			
Building Anatomy	3-0-3	3-0-3	3-0-3
Phys. 2111-2-3			
Elementary Physics	4-0-4	4-0-4	4-0-4
E.S.M. 3701-2			
Statics, Mechanics of Materials	.....	3-0-3	3-0-3
Electives¹	6-0-6	3-0-3	3-0-3
Totals	14-12-18	14-12-18	14-12-18

¹ Electives: A total of 66 hours of electives are included in the undergraduate curriculum in architecture and, with the advice of faculty counselors, they should be programmed to include the following categories; these categories will satisfy the core curriculum requirements of the College of Architecture in the humanities and social sciences, additional professional requirements of the curriculum in architecture and will allow a degree of latitude for the student to plan toward concentrated study in the graduate program.

Humanities: nine credit hours are to be devoted to English literature courses, or to appropriate modern language courses at the 3000 level or above. Note that the architectural history sequence will satisfy the remaining nine credit hours of humanities requirements.

Social Sciences: 18 credit hours, including at least three hours in each of sociology, political science, psychology and history.

General Electives: 39 credit hours may be structured to best further the student's professional goals, but must include at least six credit

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
Arch. 3001-2-3			
Architectural Design	1-12-5	1-12-5	1-12-5
Arch. 3321-2-3			
Structures and Materials	4-3-5	4-3-5	4-3-5
Arch. 3401-21-41			
Urban Planning, Facilities Planning, Building Economics	3-0-3	3-0-3	3-0-3
Electives¹	3-0-3	3-0-3	3-0-3
Totals	11-15-16	11-15-16	11-15-16

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
Arch. 4001-2-3			
Architectural Design	1-12-5	1-12-5	1-12-5
Electives¹	12-0-12	12-0-12	12-0-12
Totals	13-12-17	13-12-17	13-12-17

Senior Year Study Abroad Program

The College of Architecture Study Abroad Program is designed to give senior students in architecture the opportunity to complete all or part of their senior year in residence in Paris, France. The program offers courses paralleling those in the regular program, as well as specialized opportunities for travel and individual study interests. Students participating in the

hours of advanced architectural history and six credit hours in visual communication studio courses. Military training is an optional program of the Institute, but in case basic ROTC and advanced military are elected, no more than 15 credit hours of general electives may be used for this purpose or will be credited toward the requirements for a degree.

² See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women. (The College of Architecture will accept only the three required hours of P.E. toward meeting the requirements for a degree.)

program are registered in the Ecole des Beaux Arts and live in housing arranged by the Institute. Courses are conducted by Georgia Tech faculty; faculty of the Ecole des Beaux Arts also participate periodically with the program.

Students are encouraged to enroll in French language and culture courses at Georgia Tech prior to their senior year. This will provide better preparation for this opportunity of living, studying and traveling in Europe.

Course	1st Q.	2nd Q.	3rd Q.
Arch. 4001-2-3			
Architectural Design	1-12-5	1-12-5	1-12-5
Electives¹	12-0-12	12-0-12	12-0-12
Totals	13-12-17	13-12-17	13-12-17

¹ Electives: Same as those listed under Architecture, Senior Year.

Graduate Programs in Architecture

The graduate professional program in architecture at Georgia Tech offers a two-year course of study for persons seeking the Master of Architecture as the first professional degree and a one-year program for persons already holding a professional degree in architecture. Both programs afford the student opportunities for concentration within the professional sphere of architecture. Programs are also available for applicants holding an undergraduate degree in fields other than architecture.

The Two-Year Program

The program is structured for persons holding a four-year degree with a major in architecture from a school offering an accredited professional degree in architecture. Students having appropriate concentration in architecture in their undergraduate studies can expect to complete this program in two years. The degree awarded upon completion is the professional degree Master of Architecture which is accredited by the National Architectural Accrediting Board.

The program has three major areas of study. They are: Theories, Methods and Architecture; Urban Studies and Architecture; and Behavioral Studies and Architecture. Conceptually, these can be seen as spanning a range of contexts from the regional and urban through the building specific to the personal.

There are a number of study topics related to each of the above. For example, within Theories, Methods and Architecture is included: design theories, methods and applications; architecture and development process; and construction management. Included in Urban Studies and Architecture are: urban form; urban development; transportation; environmental design; housing; and preservation and conservation. Behavioral Studies includes: studies in environment and behavior; health facility design; and institutional building design.

The areas of study indicate only some of the choices available as topics of concentration. A minimum concentration study program has the following requirements:

Concentration course credits	12
Concentration studio credits	12
Thesis credits	18

Additional required courses	12
Electives	36
Total	90

The One-Year Program

Persons holding a first professional degree in architecture (Bachelor of Architecture; Master of Architecture or equivalent) from an accredited school of architecture are normally expected to finish the program during one academic year (50 credit hours). As with the two-year program, the course work is developed within the major study areas outlined above.

Building Construction

In tandem with the roles of the architect and engineer, the constructor assumes responsibility for bringing a building or group of buildings into physical reality. The Building Construction Program emphasizes habitable construction rather than bridges,

dams or other civil work. Basic degree requirements encompass the areas of techniques, operations and management, from which the student may then expand in directions of individual interest through a series of professional electives.

Primary objectives of the Building Construction Program are: a) to provide a set of experiences through which technical and management skills can be obtained, along with a broad educational base, to equip the student for movement toward leadership roles in the construction industry; b) to develop an educational mix that includes both practical applications and management areas such as scheduling, cost control, construction management, value engineering and estimating; c) to provide a curriculum specifically tailored to those entering the construction industry, which retains positive linkages with architecture and engineering in areas of overlap; and d) to look to the future, as well as the current "state-of-the-art," challenging current methods where appropriate and seeking superior solutions through innovation.

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Arch. 1201-2-3			
Architectural History	3-0-3	3-0-3	3-0-3
B.C. 1851			
Building Construction Seminar	.....	.....	0-3-1
Chem. 1101-2			
General Chemistry	4-3-5	4-3-5	.....
Geo.S. 2100-2			
Physical Geology	.....	.....	3-3-4
Math. 1307-8-9			
Calculus I, II, III	5-0-5	5-0-5	5-0-5
Electives²			
Physical Education	0-4-1	0-4-1	0-4-1
Electives¹	3-0-3	3-0-3	3-0-3
Totals	15-7-17	15-7-17	14-10-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Arch. 2301-2-3			
Building Anatomy	3-0-3	3-0-3	3-0-3

B.C. 2001-2-3

Design of Building Systems	1-12-5	1-12-5	1-12-5
Econ. 2000			
Microeconomics	3-0-3	.....	.....
E.S.M. 3701-2			
Statics, Strength of Materials	.....	3-0-3	3-0-3
Phys. 2111-2-3			
Elementary Physics	4-0-4	4-0-4	4-0-4
Electives¹	3-0-3	3-0-3	3-0-3
Totals	14-12-18	14-12-18	14-12-18

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
Arch. 3321-2-3			
Structures and Materials	4-3-5	4-3-5	4-3-5
B.C. 3301-2-3			
Construction Practice	3-0-3	3-0-3	3-0-3
Mgt. 3260			
Law I	3-0-3	.....	.....
Mgt. 3700			
Analysis of Financial Data	.....	3-3-4	.....
I.Sy.E. 4035			
Project Management Systems Design	.....	.....	2-3-3
Electives¹	6-0-6	5-0-5	6-0-6
Totals	16-3-17	15-6-17	15-6-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
Arch. 3421-41			
Facilities Planning, Building Economics	.....	3-0-3	3-0-3
B.C. 3441			
Building Production	3-0-3	.....	.....
Electives¹	13-0-13	13-0-13	13-0-13
Totals	16-0-16	16-0-16	16-0-16

¹ A total of 74 hours of electives are included in the curriculum in building construction and, with the advice of faculty counselors, they should be programmed to include the following categories. These categories will satisfy the core curriculum requirements of the College of Architecture in the humanities and social sciences, additional professional requirements of the building construction program and will allow a degree of latitude for the student to pursue individual interests.

Industrial Design

Industrial Design is the process of integrating beauty and utility in the design of machine-made objects and services. The field focuses on product design but also includes the design of packaging, exhibits, interiors and corporate identity. The industrial designer, with broad interests in a specialized age, is a person who must be artist, businessman and engineer combined.

The Georgia Tech program offers a well-rounded course of study with early emphasis on basic design. Projects emphasize realistic design situations; students are encouraged to develop a diverse background in order to expand individual talents and respond to changing opportunities in the field. Most faculty members are practicing designers with extensive experience in the field.

Grade averages in design courses are checked at the end of each year-group of three courses (I.D. 2001-2-3, etc.). A student is not permitted to enter a more advanced group until his or her record in the previous group equals 2.0 or better. All work executed in the college becomes the

Humanities: nine credit hours are to be devoted to English literature courses or to appropriate modern language courses at the 3000 level or above. Note that the architectural history sequence will satisfy the remaining humanities requirements.

Social Sciences: 18 credit hours, including at least one course in each of sociology, political science and psychology. Econ. 2000 will apply.

General Electives: of the remaining 47 hours, 21 hours must be selected from the list of approved professional electives in the option chosen by the student. Military training is an option of the Institute, but in case basic ROTC and advanced military are elected, no more than 15 credit hours of general electives may be used for this purpose or will be credited toward the requirements for a degree.

² See the section, "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women. (The College of Architecture will accept only the three required hours of P.E. toward meeting the requirements for a degree).

property of the college and will be retained or returned at the discretion of the faculty. The faculty also reserves the right to refuse credit for any project executed outside the precincts of the college or otherwise executed without proper coordination with the instructor.

Georgia Tech's Industrial Design program is approved by the Industrial Designers Society of America (I.D.S.A.).

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Arch. 1001-2-3			
Design Fundamentals	1-12-5	1-12-5	1-12-5
I.D. 1261-2-3			
History of Design	3-0-3	3-0-3	3-0-3
Math. 1307-8-9			
Mathematics	5-0-5	5-0-5	5-0-5
Electives³			
Physical Education	0-4-1	0-4-1	0-4-1
Electives¹	3-0-3	3-0-3	3-0-3
Totals	12-16-17	12-16-17	12-16-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
I.D. 2001-2-3			
Industrial Design	1-12-5	1-12-5	1-12-5
I.D. 2301-2-3			
Materials and Process Design	1-3-2	1-3-2	1-3-2
Phys. 2111-2-3			
Elementary Physics	4-0-4	4-0-4	4-0-4
Econ. 2000			
Microeconomics	3-0-3	.....	.....
E.S.M. 3701			
Statics	.....	3-0-3	.....
Electives¹	.....	.....	3-0-3
Electives²	3-0-3	3-0-3	3-0-3
Totals	12-15-17	12-15-17	12-15-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
I.D. 3001-2-3			
Industrial Design	1-12-5	1-12-5	1-12-5
I.D. 3301-2-3			
Materials and Process Design	1-3-2	1-3-2	1-3-2

Psy. 3303			
Psychology	3-0-3	.....	.....
I.Sy.E. 3010			
Man-Machine Systems	.....	.....	3-0-3
Electives¹	.....	3-0-3	.....
Electives²	7-0-7	7-0-7	7-0-7
Totals	12-15-17	12-15-17	12-15-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
I.D. 4001-2-3			
Industrial Design	1-16-8	1-16-8	1-16-8
Mgt. 3300			
Marketing	3-0-3	.....	.....
I.Sy.E. 3113			
Physiological and Biomechanical Analysis of Work	.....	.....	3-0-3
Electives¹	.....	3-0-3	.....
Electives²	6-0-6	6-0-6	6-0-6
Totals	10-16-17	10-16-17	10-16-17

¹ Eighteen credit hours of technical electives are to be chosen from the departmental list.

² A total of 48 additional credit hours of electives are included in the curriculum for industrial design and, with the advice of faculty counselors, they should be programmed to include the categories below. These categories will satisfy the core curriculum requirements of the College of Architecture in the humanities and social sciences, additional professional requirements of industrial design and will allow a degree of latitude for the student to pursue individual interests.

Humanities: nine credit hours are to be devoted to English literature courses or to appropriate modern language courses at the 3000 level or above.

Social Sciences: 18 credit hours including at least one course each in sociology, political science and psychology.

General Electives: 21 credit hours may be structured to best further the student's professional goals, but must include at least six credit hours in visual communication studio courses. Military training is an option of the Institute, but, in case basic ROTC and advanced military are elected, no more than 15 credit hours of general electives may be used for this purpose or will be credited toward the requirements for a degree.

³ See "Curricula and Degrees," Department of

Graduate Program in City Planning

The Graduate City Planning Program seeks to give students a broad knowledge and understanding of the forces which shape our urban environment and to develop specific skills for directing and managing this changing urban environment over time. The program offers a professional education designed to prepare students for careers as public sector planners at all levels: neighborhood, city, regional, state or federal, and as private sector planners in business institutions. Two major objectives are emphasized: the ability to develop implementable long- and short-range plans for satisfying the needs of urban areas, and the skill to evaluate the effectiveness of policies and programs established to address urban problems.

To meet this goal of training urban-oriented planners, 75 percent of the program is a common requirement for all students. The remaining 25 percent is devoted to the teaching of such specialties as environment, water resources, quantitative methods, economic analysis, economic development, public finance, public administration, real estate development (jointly with Georgia State University), urban design, housing, crime prevention and transportation.

Three types of degree programs are available for students interested in the fields of urban and regional planning: the two-year professional Master of City Planning degree (recognized by the American Institute of Certified Planners for membership purposes), the joint Master of City Planning and Master of Science in a related field and the undesignated Master of Science degree (not recognized by the

Physical Education and Recreation, for freshman physical education requirements for both men and women. (The College of Architecture will accept only the required three hours of P.E. toward the requirements for a degree).

American Institute of Certified Planners but considered a degree in a related field for membership purposes).

Master of City Planning Degree

The two-year curriculum requires, for most students, five quarters of course work, one quarter for a thesis and a minimum of one quarter as an intern in the office of an approved planning agency. Required courses are: Engl. 3019, C.P. 6000, 6010, 6020, 6030, 6060, 6090, 6100, 6110, 6120, 6140, 6210, 6260, 6270, 6350, 6360, C.E. 6704, Soc. 6375 and electives—nine credit hours.

With the approval of his or her faculty adviser, a student may substitute 25 credit hours in a field of specialization instead of the thesis provided the student has appropriate undergraduate preparation. At least six credit hours must be in independent study.

Joint Degree in Urban Design

A joint degree program is offered in urban design as a cooperative effort between the architecture and city planning programs. Students completing this program receive the Master of Architecture and the Master of City Planning degrees. The program requires a minimum of 100 hours (two years) for those who hold the Bachelor of Architecture degree and 134 hours (two and two-thirds years) for those who hold the Bachelor of Science degree.

COLLEGE OF ENGINEERING

Dean—William M. Sangster; *Associate Dean*—W. Denney Freeston; *Assistants to the Dean*—Carolyn C. Chesnutt, Coleen A. Donahue.

General Information

The College of Engineering comprises 11 degree-granting schools of instruction and research. The ten schools of engineering offer programs of study and research leading to bachelor's, master's and doctoral degrees and the School of Health Systems offers programs leading to bachelor's and master's degrees. Certain of these schools also offer programs in one or more subdisciplines or specialties. These degree offerings are summarized in the following table.

College of Engineering Degree Programs

	B	M	PhD
Aerospace Engineering	X	X	X
Ceramic Engineering	X	X	X
Chemical Engineering	X	X	X
Metallurgy		X	X
Civil Engineering	X	X	X
Sanitary Engineering		X	X
Electrical Engineering	X	X	X
Engineering Science and Mechanics	X	X	X
Health Systems	X	X	
Industrial and Systems Engineering	X	X	X
Operations Research		X	X
Mechanical Engineering	X	X	X
Nuclear Engineering	X	X	X
Health Physics	X	X	X
Textile Engineering	X	X	X
Textile Chemistry	X	X	
Textiles	X	X	

The programs in engineering are designed to provide a fundamental understanding of the engineering sciences, which are based on mathematics and the natural sciences; and of the basic concepts of the humanities and social sciences; then to furnish an understanding of the manner in which these elements are interwoven in engineering practice. Each curriculum provides enough flexibility through elective course opportunities to permit a certain amount of program individualism, even as basic requirements are met.

Freshman Engineering Electives

Any of the following courses are acceptable for credit as freshman engineering electives in all curricula in engineering: E.Gr. 1171, A.E. 1350, Cer.E. 1010, Ch.E. 1110, 1750, C.P. 1750, C.E. 1503, E.E. 1010, 1011, 1750, E.S.M.1101, 1750, H.S. 2011, I.Sy.E. 1010, M.E. 1110, 1750, N.E. 1100, Text. 1100.

Multidisciplinary Programs in Engineering

In addition to its degree programs, the College of Engineering provides unusual opportunities for specialized study in engineering through its multidisciplinary certificate program offerings. Any student in good standing who is pursuing a degree through one of the eleven schools of the college, or through the College of Architecture, may so select elective courses and the subjects of special problems or thesis research as to satisfy simultaneously both the requirements of his or her major degree program and the requirements of a specialized multidisciplinary program, provided that the school through which the standard degree is being sought is a participant in that program. Upon graduation, the successful student receives both the degree in the major field of study and a certificate attesting to successful completion of the particular related multidisciplinary program.

The table on page 71 shows both currently available multidisciplinary program offerings (identified by X's) and those which are in the planning stage (identified by as-

terisks), as well as the levels of the major degree programs with which they are associated. It should be noted that the planning process in certain multidisciplinary program areas includes inputs from certain schools and departments from outside the College of Engineering and that nonengineering-designated multidisciplinary certification is potentially available to Institute students from outside that college.

General Requirements of Undergraduate Multidisciplinary Programs

The specific design of the multidisciplinary program of any participating undergraduate student, while as individualized as possible, must meet certain general requirements as well as requirements that are specific to that multidisciplinary area. The general (minimum) undergraduate multidisciplinary requirements are: (1) the program must relate the student's major area to the given multidisciplinary area; (2) courses must be taken under more than one academic unit; (3) at least four courses and 12 credit hours (not required by name and number in the student's major) must be taken in a coherent program; (4) at least three of those courses and nine credit hours must be at the 3000 level or higher; (5) at least two of those courses and six credit hours must be outside the major field (crosslisted courses may be counted outside the student's major); (6) a grade of C or better must be earned in each course counting toward a multidisciplinary certificate.

General Requirements of Graduate Multidisciplinary Programs

The specific design of the multidisciplinary program of any participating graduate student, while as individualized as possible, must meet certain general requirements as well as requirements that are specific to that multidisciplinary area. The general (minimum) graduate multidisciplinary requirements are the same as those listed above for the undergraduate programs, with the following exceptions: (1) at least three of the coherent multidisciplinary program courses as well as nine credit hours must be at the 6000 level or higher; (2) a

grade of B or better must be earned in each course counting toward a multidisciplinary certificate; (3) students at the doctoral level must, on an individual basis, meet additional requirements specified by the student's doctoral committee, consistent with a program beyond the master's level whose objective is to develop a doc-

toral level multidisciplinary program. Detailed information and specific requirements of the various undergraduate-level and graduate-level multidisciplinary programs may be obtained through the Office of the Dean, College of Engineering.

Multidisciplinary Program Pattern															
Multidisciplinary Program Area	Related Degree Levels														
		Aerospace Engineering	Ceramic Engineering	Chemical Engineering	Civil Engineering	Electrical Engineering	Engineering Science & Mechanics	Health Systems	Industrial and Systems Engineering	Mechanical Engineering	Nuclear Engineering	Textile Engineering	Architecture	Biology	Chemistry
Acoustical Engineering	M PhD	X			*	X	X		X	X		X	X		*
Bioengineering	B M PhD	X	X	X	X	X	X	*	X	X	X	X	*	*	
Computer Engineering	M PhD	X	*	X	X	X	*	*	X	X	X	*	*		*
Energy Engineering	B M PhD	X	X	*	*	X	X		X	X	X	X	X		
Engineering Design	B M PhD	*		*	*	*	*		*	*	*	*	*		
Environmental Studies	M PhD	X	*	X	X	X	X		X	X	X	*	*	*	*
Manufacturing Systems	B			*		*			*	*	*	*	*	*	*
Materials Engineering	B		X	X	X	X	X		X	X	X	X	*		*
Mineral Engineering	M PhD		X	X	X					X					
Plastics Engineering	B M PhD	*	X	X	*		*		X		X	*			
Pulp and Paper Engineering	B		X	X			X		X		X	X		*	
Structures Engineering	M PhD	X			X	X	*		*	*	*	*	*		
Systems Engineering	M PhD	*		*	*	*	*	*	*	*	*	*	*		
Transportation Engineering	M PhD	X			X	X	X		X	X		*			
Urban Engineering	B				X	X	X	X	X	X		X			

X = Established Programs * = Programs in Planning Stage

School of Aerospace Engineering

Daniel Guggenheim
School of Aeronautics,
Established in 1930

Director—Arnold L. Ducoffe; *Associate Director and Regents' Professor*—Robin B. Gray; *Regents' Professors*—Warren C. Strahle, Ben T. Zinn; *Professors*—Robert L. Carlson, Howard D. Edwards, Don P. Giddens, Sathyanarayana V. Hanagud, John J. Harper, Wilfred H. Horton, James E. Hubbart, Howard M. McMahon, G. Alvin Pierce, Edward W. Price, Lawrence W. Rehfield, James C. Wu; *Associate Professors*—Stanley C. Bailey, James I. Craig, C. Virgil Smith, Jr.; *Assistant Professors*—Jechiel I. Jagoda, Spyridon G. Lekoudis.

General Information

The School of Aerospace Engineering prepares students at the bachelor's, master's and doctoral levels for a career in vehicle engineering with primary emphasis on flight vehicles. The school is housed in three buildings having a floor space of 85,000 square feet with a majority of this space devoted to instructional and research laboratories.

Undergraduate Programs

The first two years focus on course work in the areas of chemistry, mathematics, physics, humanities and social sciences. Aerospace disciplines and related engineering sciences are emphasized in the third and fourth years. The undergraduate curriculum is designed to provide each student with a general background for either industry or graduate school at the end of four years. The program stresses both the theoretical and experimental aspects of aerospace engineering.

A certain degree of specialization is available to undergraduate students through the proper choice of electives or certain substitutions for required courses or both, depending on the student's abilities and career objectives. These specialized

disciplines are acoustics, aeroelasticity, aerospace vehicle design, bioengineering, experimentation and instrumentation, fluid dynamics of pollution, helicopters and V/STOL aircraft, propulsion, structural dynamics, structures and supersonic and hypersonic vehicles.

A premed track is available to undergraduate students. This requires an additional academic year of chemistry and one academic year of biology. Students may substitute these courses for the electives and for certain required courses in the present curriculum.

Graduate Programs

The graduate programs at both the master's and doctoral levels are flexible so that students may tailor their course and research work to individual career objectives. The following areas of specialty are available.

Aeroelasticity

Dynamic response and loads, flutter, servo-aeroelastic instabilities and control, static aeroelastic instabilities and loading, unsteady aerodynamics—V/STOL and conventional aircraft and vibrational characteristics of vehicles.

Fluid Mechanics

Atmospheric boundary layer flows, computational fluid dynamics, helicopter aerodynamics, laminar and turbulent flows, plasma and reacting gas dynamics, rarefied gas flows, statistical theory of turbulence and V/STOL aircraft.

Propulsion

Combustion instability, external burning, propulsion system noise, solid rocket propellant research and supersonic combustion.

Structures

Buckling and postbuckling of structures, composites, elastic and inelastic stress analysis, fracture mechanics, fatigue behavior, structural reliability and statistical methods of structural analysis, vibration and dynamic stability of structural elements, wave propagation and use of acoustic emission methods.

Urban and Societal Engineering

Air pollution, biomechanics, fire research and noise pollution.

Facilities for each of the above academic areas are housed in the aerospace laboratories. They include low speed, high speed, MHD and low density wind tunnels, anechoic chamber, combustion chamber, combustion bomb, helicopter test stand, high and low temperature test machines, fatigue and creep machines, humidity chamber, environmental test chamber, analog and digital computers, data acquisition systems, fourier analyzers, scanning electron microscope and associated instrumentation, such as transducers, lasers, tape recorders, etc.

The facilities are supported by extremely competent personnel and a well-equipped instrument lab and machine shop.

Multidisciplinary Programs

See table on page 71.

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Elective			
E.Gr. 1170, Introduction to Visual Communication and Engineering Design I (2-3-3) and one of the engineering electives ¹	X-X-3	X-X-3	.....
Chem. 1101-2			
Inorganic Chemistry	4-3-5	4-3-5	.....
Math. 1307-8-9			
Calculus I, II, III	5-0-5	5-0-5	5-0-5
Phys. 2121			
Physics	.....	.....	4-3-5
Electives²			
Humanities/Social Science/Modern Language	3-0-3	3-0-3	6-0-6
Electives³			
Free	.....	.....	3-0-3
Electives⁴			
Physical Education	0-4-1	0-4-1	0-4-1
Totals	14-10-17	14-10-17	18-7-20

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
A.E. 2101			
Introduction to Aircraft Structures	.....	.....	4-0-4
A.E. 2603			
Digital Computers	.....	.....	1-6-3
E.S.M. 2201			
Statics	3-0-3	.....	.....
E.S.M. 3201			
Dynamics I	.....	3-0-3	.....
Math. 2307			
Calculus IV	5-0-5	.....	.....
Math. 2308			
Calculus and Linear Algebra	.....	5-0-5	.....
Math. 2309			
Ordinary Differential Equations	.....	.....	5-0-5
M.E. 3322			
Thermodynamics	.....	.....	3-0-3
Phys. 2122-3			
Physics	4-3-5	4-3-5	.....
Electives²			
Humanities/Social Science/Modern Language	3-0-3	3-0-3	.....
Electives³			
.....	.....	.....	3-0-3
Totals	15-3-16	15-3-16	16-6-18

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
A.E. 3000-1-2			
Fluid Mechanics I, II, III	4-3-5	4-3-5	4-3-5
A.E. 3103			
Fundamentals of Stress Analysis	3-0-3	.....	.....
A.E. 3104			
Energy Methods and Stability of Structures	.....	3-0-3	.....
A.E. 3110			
Structures Lab	1-3-2	.....	.....
E.E. 3700			
Circuits and Instruments	3-0-3	.....	.....
E.E. 3710			
Electronic Systems	.....	3-0-3	.....

E.E. 3740 Instrumentation Laboratory	0-3-1	.....	.....
E.E. 3741 Electronic Systems	.....	0-3-1	.....
E.S.M. 4210 Mechanical Vibrations	.....	.....	3-0-3
Math. 4582 Advanced Engineering Math	.....	.....	3-0-3
Electives² Humanities/Social Science/ Modern Language	3-0-3	6-0-6	6-0-6
Totals	14-9-17	16-6-18	16-3-17

Senior Year			
<i>Course</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
A.E. 4000 Fluid Mechanics IV	4-3-5	.....	.....
A.E. 4101 Analysis of Thin-walled Structural Elements	3-0-3	.....	.....
A.E. 4102 Selected Topics in the Analysis of Aircraft Structures	.....	.....	3-0-3
A.E. 4110 Structures Lab	1-3-2	.....	.....
A.E. 4200 Vibration and Flutter	.....	.....	3-0-3
A.E. 4250 Jet Propulsion	.....	5-0-5	.....
A.E. 4350-1 Aerospace Engineering Design Project I, II	.....	2-6-4	2-6-4
A.E. 4410 Vehicle Performance	3-0-3	.....	.....
A.E. 4500 Stability and Control	.....	5-0-5	.....
Electives² Humanities/Social Science/ Modern Language	.....	.....	3-0-3
Electives⁵ Free	3-0-3	3-0-3	3-0-3
Totals	14-6-16	15-6-17	14-6-16

School of Ceramic Engineering

Established in 1924

Director—Joseph L. Pentecost; *Professors*, A. T. Chapman, Willis E. Moody; *Associate Professor*—James F. Benzel; *Assistant Professor*—Joe K. Cochran, Jr.; *Research Engineer and Lecturer*—David N. Hill; *Special Lecturers*—R. A. Young and Robert Lane Mitchell.

General Information

The ceramic industry produces over \$20 billion worth of products annually in the United States. These products range from brick, tile, glass, portland cement and dinnerware to high-temperature refractories for furnace linings, abrasives and sophisticated electronic components. These traditional products create a continuing demand for personnel trained in this field and new products which are continuously developing open new opportunities. Over the past 20 years these new products have included rocket nozzles and jet engine components, electronic circuitry for computers and fiberglass products for nose cones and missiles. Current developments include automotive exhaust catalyst supports and

¹ See College of Engineering section "Curricula and Degrees" for engineering electives.

² Eighteen credit hours in humanities and 18 credit hours in social science are required for graduation. To satisfy these requirements, humanities and social science courses must be selected from the College of Engineering listings in "Information for Undergraduate Students."

³ These free elective courses may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, ROTC should be scheduled the first quarter the student is enrolled.

⁴ See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

⁵ Free electives. Not more than nine credit hours of advanced ROTC may be applied toward the requirements for a degree.

other pollution control devices, new lighting techniques and electrooptical materials.

The raw materials for ceramic products are the most plentiful minerals in the earth's crust. Consequently, many are relatively cheap and result in durable, economical, temperature-resistant materials that are in continuous demand for innovative design.

Ceramic engineering applies sound scientific and engineering principles to solve manufacturing problems in the industry. Frequently these problems are complex and challenging for chemical and physical reactions are occurring at high temperatures. Measurements are difficult and cost constraints for economical production are always present.

The School of Ceramic Engineering offers a four-year curriculum leading to the bachelor's degree and graduate work leading to Master of Science and Doctor of Philosophy degrees in ceramic engineering. The undergraduate curriculum is designed to prepare the degree candidate for a position in the ceramic industry or for graduate work. Courses are also offered to nonmajors to introduce them to ceramic materials and processes or to develop specific skills and knowledge in the application of ceramic materials.

Multidisciplinary Programs

See table on page 71.

Freshman Year

<i>Course</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Chem. 1111-2 General Chemistry	4-3-5	4-3-5	.....
Chem. 2113 Chemical Principles	.....	.....	3-3-4
Elective E.Gr. 1170, Introduction to Visual Communication and Engineering Design I (2-3-3) and one of the engineering electives ¹	X-X-3	X-X 3	.....
Math 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
Electives³ Physical Education	0-4-1	0-4-1	0-4-1

Electives

Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives² Free	2-0-2	2-0-2	2-0-2
Totals	16-10-19	16-10-19	13-7-15

Sophomore Year

<i>Course</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Cer.E. 3001 Ceramic Data Handling	.....	.....	2-3-3
Cer.E. 3002 Properties of Engineering Materials	.....	.....	2-3-3
E.S.M. 2201 Statics	3-0-3	.....	.....
E.S.M. 3201 Applied Mechanics	.....	3-0-3	.....
Math. 2307 Calculus IV	5-0-5	.....	.....
Math. 2308 Calculus and Linear Algebra	.....	5-0-5	.....
Phys. 2121-2-3 Physics	4-3-5	4-3-5	4-3-5
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	6-0-6
Electives² Free	.....	.....	2-0-2
Totals	15-3-16	15-3-16	16-9-19

Junior Year

<i>Course</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Cer.E. 3003 Ceramic Processing I	3-3-4	.....	.....
Cer.E. 3004 Ceramic Processing II	.....	2-3-3	.....
Cer.E. 3005 Phase Equilibria for Ceramists	3-0-3	.....	.....
Cer.E. 3006 Physical Ceramics I	3-0-3	.....	.....
Cer.E. 3007 High Temperature Analysis	.....	2-3-3	.....

Cer.E. 3008 Glass Technology I	.....	2-3-3	.....
Cer.E. 4018 Drying and Psychrometry	.....	.....	2-0-2
Cer.E. 4052 Inorganic Phase Analysis and Identification	.....	.....	3-3-4
Chem. 3412-3 Physical Chemistry	.....	3-0-3	3-0-3
Chem. 3481 Physical Chemistry Laboratory	.....	.....	0-6-2
Geo.S. 2100 General Geology	3-0-3	.....	.....
Geo.S. 2102 General Geology Laboratory	0-3-1	.....	.....
E.S.M. 3301 Mechanics of Deformable Bodies	.....	.....	5-0-5
Electives Humanities/Social Science/Modern Language	.....	3-0-3	3-0-3
Electives Free	2-0-2	3-0-3	.....
Totals	14-6-16	15-9-18	16-9-19

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
Cer.E. 4002 Refractories and Combustion	3-3-4	.....	.....
Cer.E. 4003 Physical Ceramics II	.....	2-3-3	.....
Cer.E. 4004 High Temperature Thermodynamics	.....	2-0-2	.....
Cer. E. 4005 Glass Technology II	2-3-3	.....	.....
Cer.E 4010-1-2 Technical Management and Design Problems I, II, III	1-3-2	0-6-2	0-3-1
Cer.E. 4015-6-7 Independent Research Project I, II, III	1-0-1	1-3-2	0-6-2

I.Sy.E. 4725 Engineering Economy	.....	.....	3-0-3
Elective Either E.E. 3700, Elements of Electrical Circuits and Instruments (3-0-3) or E.E. 3725, Electric Circuits and Fields (2-3-3)	.....	.....	X-X-3
Elective Metallurgy	3-0-3	.....	.....
Elective Humanities/Social Science/Modern Language	3-0-3	6-0-6	.....
Elective Free	.....	3-0-3	6-0-6
Totals	13-9-16	14-12-18	11-12-15

¹ See College of Engineering section "Curricula and Degrees" for engineering electives.

² These free elective courses may be taken at any time during a student's course of study.

³ See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

School of Chemical Engineering

Established in 1901

Director and Professor—Gary W. Poehlein; *Chemical Engineering Faculty—Regents' Professor*—Clyde Orr, Jr.; *Professors*—Charles W. Gorton, H. Clay Lewis, Michael J. Matteson, John D. Muzzy, Robert J. Samuels, A. H. Peter Skelland, Jude T. Sommerfeld, Henderson C. Ward, Jack Winnick; *Associate Professors*—Larry J. Forney, William R. Ernst, Edwin M. Hartley, Amyn Teja; *Assistant Professors*—Pradeep K. Agrawal, Allan S. Myerson, Ronnie S. Roberts, William D. Tedder, Mark G. White, Ajit P. Yoganathan; *Lecturer*—Charles J. Aloisio, Jr.; *Adjunct Professors*—John H. Burson, George A. Fowles, Roy A. Wiggins, Jr., Charles Aloisio; *Metallurgy Faculty: Associate Director and Professor*—

Robert F. Hochman; *Professors*—Helen Grenga, John Husted, Stephen Spooner, Edgar A. Starke, Jr., Ervin E. Underwood; *Associate Professors*—Miroslav Marek, Pieter Muije; *Research Scientists*—Saghana Chakraborty, Thomas H. Sanders, Jr.; *Research Engineer*—Ludmilla Konopasek.

Chemical Engineering Program

General Information

Chemical engineers perform essential functions in industries that convert raw materials into useful finished products by means of chemical and physical processes. Almost every major manufacturing industry employs chemical engineers in research, development, design, production, sales, consulting and management positions. Substantial numbers of chemical engineers are employed in petroleum, petrochemical, pulp and paper, plastics, metallurgical, fiber, fertilizer, nuclear energy, space, rubber, food, photographic, heavy and fine chemical, mineral, pharmaceutical, textile and dye industries. Energy problems and environmental and pollution control activities require an increasing number of chemical engineers.

The School of Chemical Engineering offers programs leading to the degrees Bachelor of Chemical Engineering, Master of Science in Chemical Engineering, Master of Science in Metallurgy and Doctor of Philosophy. The doctoral program may be in either chemical engineering or metallurgy. Interdisciplinary programs and undesignated degrees are also available.

The following curriculum leads to the degree of Bachelor of Chemical Engineering and is designed to train students both for positions immediately upon graduation or for additional study leading to the master's and doctoral degrees.

It is a requirement of the School of Chemical Engineering that every required chemical engineering course be passed with a grade of C or better.

A six-week summer study program in the Department of Chemical Engineering of the

University College London in London, England was initiated in the summer quarter, 1975. Selected juniors who participate in this program are allowed 12 credit hours of free or technical electives, some of which may be substituted for some of the chemical engineering laboratory courses.

Graduate Programs

The School of Chemical Engineering has a graduate program of advanced study and research in chemical engineering and metallurgy. Graduate activities in metallurgy are described in detail within the general description of the Metallurgy Program which follows. Chemical engineering graduate work can lead to the Master of Science Degree and the Doctor of Philosophy Degree. Both degrees involve a combination of advanced level courses and independent research or design work.

Master's degree candidates are required to complete a research or design thesis. Course selection for both the master's and doctoral degrees is quite flexible with individual plans of study developed for each student.

Research opportunities exist in a broad range of areas of importance to chemical engineers and society. Some of these areas are: air pollution control, biochemical engineering, polymer science, process design and simulation, chemical reaction engineering, development of alternate energy sources, biomedical engineering, pulp and paper engineering, transport phenomena, fine particle technology, minerals processing, thermodynamics and electrochemical engineering.

Fracture and Fatigue Research Laboratory

The Fracture and Fatigue Research Laboratory (FFRL) was established to encourage interdisciplinary research and educational opportunities in the field of fracture and fatigue of materials. Faculty members representing various academic departments of Georgia Tech, as well as staff members of the Engineering Experiment Station (EES), are involved in its ac-

tivities. Research in the FFRL is focused on the fracture and fatigue behavior of engineering materials. The research programs are interdisciplinary, based on a combined fracture mechanics-materials science point of view. Projects involving the behavior of metals, ceramics, polymers and composites all fall within the scope of the laboratory.

Graduate students participating in FFRL research usually enroll for the master's or doctoral degree in the traditional discipline of their choice. However, they pursue coursework related to a broader understanding of materials and they benefit from the association with other students and faculty in the interdisciplinary setting. Students with backgrounds in materials science, metallurgy, ceramics, chemistry, physics or any branch of engineering are encouraged to apply.

Metallurgy Program

General Information

The field of metallurgy is a vital component in our economy because of its central contribution to the selection and use of metals in all engineering and scientific fields. The program offers a master's degree in metallurgy and a doctoral degree. An excellent selection of undergraduate courses is offered in preparation and support of graduate studies. Course offerings and research activities cover a range of subject areas in the broad field of metallurgy. Subjects include mining engineering, extractive metallurgy, chemical metallurgy, corrosion science and engineering, physical metallurgy, mechanical metallurgy and metallurgical fabrication.

For undergraduates desiring to specialize in metallurgy, an undesignated degree program can be pursued which is equivalent in Engineers' Council for Professional Development (ECPD) requirements to an accredited degree at any other school.

Research facilities are among the program's strongest features. Excellent general corrosion laboratory equipment is part of the corrosion research facilities in which

hydrogen embrittlement, metal dusting, stress, corrosion, cracking, and medical implant and dental material investigations are carried out. Structural investigations of metals and alloys are done in the X-ray laboratory having a variety of general equipment and in the electron microscopy laboratories. These labs house a Siemens research electron microscope and the newly-acquired TEM-100C scanning transmission electron microscope, which is the most advanced equipment in the field. Metallographic equipment, heat treatment furnaces and alloy melting equipment allow investigators to design and produce new materials. Mechanical testing facilities include both standard and specialized equipment, most notably the MTS universal mechanical testing equipment now being used for fatigue research in a range of alloys.

Graduates find employment with manufacturing firms in light and heavy industry and in research laboratories of private firms and federal agencies. Several recent graduates have filled positions of high responsibility in the Atlanta area and have been instrumental in advancing the level of materials engineering practice in Georgia.

The Metallurgy Program faculty participate in several multidisciplinary programs, including materials engineering, mineral engineering, manufacturing engineering, biomedical engineering and in the interdisciplinary program in surface science technology.

The Master's Degree

The program in metallurgy offers graduate work leading to the degree of Master of Science in Metallurgy. The student admitted for graduate work will normally have completed an undergraduate program in metallurgy or metallurgical engineering. However, students with undergraduate degrees or backgrounds in other fields (e.g., physics, chemistry, geology; chemical, ceramic, mechanical, nuclear or geological engineering) may qualify by taking certain minimum prerequisites during the early part of his or her graduate studies. To assure a smooth transition into the graduate Metal-

lurgy Program, the student is encouraged to select appropriate electives during his or her undergraduate studies.

The Master of Science in Metallurgy curriculum offers two options: (1) physical metallurgy and (2) chemical metallurgy. Both have a common core of basic studies but differ in other aspects. Specialization in one of these areas does not alter the Master of Science degree. The student's individualized program of study for this degree must be prepared in conference with his or her graduate adviser. The proposed program must receive the approval of the graduate adviser and the director and will include a thesis.

Physical Metallurgy

This option deals with the relationships between chemical composition, structure and properties of metals and alloys. Activities of the physical metallurgist include the study of atomic structure of solids, alloy development and the mechanical, physical and corrosion behavior of metals and alloys in engineering applications.

Chemical Metallurgy

This option deals with the concentration of minerals from natural resources and the extraction of pure metal from these concentrates. Recycling of metal scrap and other waste products is also a specialty of the chemical metallurgist. The industries that usually require the services of the chemical metallurgist are iron, steel, aluminum, copper and other basic metal producers. In addition, the chemical metallurgy option deals with the fundamental characteristics of metal and alloy deterioration (corrosion) and the properties and structures of metal surfaces (surface science) in liquid and gas environments.

The Doctoral Degree

The Doctor of Philosophy degree is directed toward the goal of attaining proficiency in the conduct of independent scholarly work. The degree program comprises course work in the principles of metallurgy, additional specialized courses both in the area of the doctoral thesis and in one

or two other areas, demonstration of reading competence in a foreign language, the passing of a comprehensive examination and an independent research investigation.

Except for the requirement that 15 credit hours must be earned in a minor field, which may be any technical or nontechnical field that the student chooses, there are no definite course requirements for the doctoral degree in metallurgy. Most students find that they will schedule about 60 to 70 hours of courses.

Students are encouraged to commence participation in the departmental research programs early in their graduate careers. The undertaking of a doctoral thesis is usually reserved until the candidacy examination is passed, which may occur during the second graduate year for a well-prepared student.

Financial Aid

Financial assistance is usually available to the qualified graduate student in the Metallurgy Program. A number of fellowships and research assistantships from outside sources are available for this purpose. In addition, a limited number of Presidential Fellowships, Teaching and Research Assistantships are available from the Institute. Industrial support is also available. Waiver of out-of-state tuition is possible for qualified students. Further information can be obtained by writing the director of the School of Chemical Engineering.

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Ch.E. 1101 Introduction to Chemical Engineering	1-0-1	.....	.....
E.Gr. 1170 Visual Communication	.....	.....	2-3-3
Chem.¹ 1111-2 General Chemistry	4-3-5	4-3-5	.....
Chem. 2113 Chemical Principles	.....	.....	3-3-4
Engl.² 1001-2-3 Introduction to Literature	3-0-3	3-0-3	3-0-3

Math. 1307-8-9			
Calculus	5-0-5	5-0-5	5-0-5
Elective³			
Freshman Engineering Elective	.....	X-X-3	.....
Electives⁴			
Freshman Physical Education	0-4-1	0-4-1	0-4-1
Electives⁵	3-0-3	.....	3-0-3
Totals	16-7-18	14-10-17	16-10-19

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Ch.E. 2207-8			
Chemical Process Principles	3-0-3	3-0-3	.....
Ch.E. 2209			
Computers in Chemical Engineering	.....	.....	2-3-3
Ch.E. 3300			
Transport Phenomena	.....	.....	3-0-3
Math. 2307-8			
Calculus	5-0-5	5-0-5	.....
Phys. 2121-2-3			
Physics	4-3-5	4-3-5	4-3-5
Chem. 3311-2-3			
Organic Chemistry	3-0-3	3-0-3	3-0-3
Chem. 3381			
Organic Chemistry Laboratory	.....	0-6-2	.....
Electives	.....	.....	3-0-3
Totals	15-3-16	15-9-18	15-6-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
Ch.E. 3301			
Transport Phenomena	3-0-3	.....	.....
Ch.E. 3302-3			
Transport Phenomena Laboratory	0-3-1	0-3-1	.....
Ch.E. 3306-7			
Unit Operations	.....	3-0-3	3-0-3
Chem. 3411-2-3			
Physical Chemistry	3-0-3	3-0-3	3-0-3
Chem. 3481			
Physical Chemistry Laboratory	.....	.....	0-6-2

E.S.M. 2201			
Statics	3-0-3	.....	.....
E.E. 3700			
Electrical Circuits and Fields	.....	.....	3-0-3
E.E. 3740			
Electrical Engineering Laboratory	.....	.....	0-3-1
Met. 3301			
Engineering Materials	.....	4-3-5	.....
Electives	6-0-6	6-0-6	6-0-6
Totals	15-3-16	16-6-18	15-9-18

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
Ch.E. 4438			
Chemical Engineering Thermodynamics	4-0-4	.....	.....
Ch.E. 4415			
Reactor Design	.....	3-0-3	.....
Ch.E. 3308			
Unit Operations	3-0-3	.....	.....
Ch.E. 3309-10			
Unit Operations Laboratory I, II	0-3-1	0-3-1	.....
I.C.S. 2250			
Technical Information Resources	1-0-1	.....	.....
Ch.E. 4431			
Chemical Engineering Economics	3-0-3	.....	.....
Ch.E. 4432			
Process and Equipment Design	.....	2-3-3	.....
Ch.E. 4434			
Plant Design	.....	.....	1-6-3
Ch.E. 4416			
Process Control	.....	3-3-4	.....
Electives	6-0-6	6-0-6	12-0-12
Totals	17-3-18	14-9-17	13-6-15

Multidisciplinary Programs

See table on page 71.

¹ Chem. 1111-2, advanced level chemistry, is required for all chemical engineering majors. Students transferring into chemical engineering from other curricula not requiring the advanced level chemistry will be allowed to substitute Chem. 1101-2 for Chem. 1111-2, respectively, if taken prior to transferring.

² Engl. 1001-2-3 is required for all chemical engineering majors and satisfies nine hours of the humanities requirement. Students transferring into chemical engineering from other curricula not requiring Engl. 1001-2-3 or students granted advanced placement will be allowed to substitute any nine hours of humanities for Engl. 1001-2-3. International students may substitute Engl. 1031-2-3 for Engl. 1001-2-3 and six hours of electives; only Engl. 1033 may be used as a humanities requirement (Also see Note 5).

³ See "Curricula and Degrees," College of Engineering section, for acceptable freshman engineering electives.

⁴ See "Information for Undergraduate Students," Physical Education Credit, for freshman physical education requirements.

⁵ The chemical engineering curriculum contains 54 hours of electives to be chosen from five groups in the normal distribution indicated to satisfy the requirements of the College of Engineering and the School of Chemical Engineering—humanities (9), social sciences (18), technical (9), physical education (3) and free (15). These electives may be taken at any time and in any order during the student's course of study. Up to 12 hours of these electives may be taken on a pass-fail basis.

Humanities and Social Sciences Electives—See "Information for Undergraduate Students," Humanities and Social Sciences Requirements, for the College of Engineering requirement and a listing of acceptable electives in these two groups (Also see Note 2). Students should also see the Constitution and History Examinations section in "Information for Undergraduate Students." Modern language is recommended for students considering graduate work.

Technical Electives—The technical requirement of the School of Chemical Engineering may be satisfied by any nine hours of advanced technical or scientific courses provided the course is not repetitious of a previous course. A suggested list of technical electives is available from the chemical engineering office and all questions concerning this requirement should be directed to the chemical engineering office. It is recommended that the technical electives be taken in the junior and senior years.

Free Electives—Fifteen hours of free electives are provided so that a student will be able to pursue specific interests. See the ROTC Credit section for the maximum hours in this area that may be applied toward degree requirements. If six credit hours of basic ROTC are elected, they should be scheduled beginning the first quarter the student is enrolled. Only three credit hours of Physical Education can be used for free electives. No course which covers the same material

as other courses in a student's plan of study can be used as a free elective.

School of Civil Engineering

Established in 1896

Director—J. Edmund Fitzgerald; *Assistant Director*—Paul H. Sanders; *Regents' Professors*—Satya N. Atluri, Paul G. Mayer, George F. Sowers; *Professors*—Richard D. Barksdale, Austin B. Caseman, Edward S. K. Chian, Donald O. Covault, Leroy Z. Emkin, James S. Lai, Charles S. Martin, Gene M. Nordby, Frederick G. Pohland, William M. Sangster, Thomas E. Stelson, Paul H. Wright; *Associate Professors*—Larry J. Forney, Barry J. Goodno, Daniel W. Halpin, John D. Hutcheson, Billy B. Mazanti, Paily P. Paily, Peter S. Parsonson, Quentin L. Robnett, F. Michael Saunders, Calvin W. Tooles, Earl M. Wheby, I. Edwin Wilks; *Assistant Professors*—Roland Gareis, Joseph P. Gould, Achintya Haldar, Edward R. Johnson, Lawrence F. Kahn, Sai Lee, Srinivasa R. G. Rao, Philip J. W. Roberts, Terry W. Sturm, Makram T. Suidan, Kenneth M. Will; *Lecturer*—Mustafa M. Aral; *Instructors*—Robert C. Bachus, Larry W. Hess, Michael H. Swanger, Hyman A. Todres; *Adjunct Professor*—Patrick M. Quinlan.

General Information

The School of Civil Engineering offers courses in civil engineering and engineering graphics and programs leading to the degrees Bachelor of Civil Engineering, Bachelor of Science (undesignated), Master of Science in Civil Engineering, Master of Science in Sanitary Engineering, Master of Science (undesignated) and Doctor of Philosophy. Also offered is a joint two-year program leading to the awarding of the degrees Master of Science in Civil Engineering or Master of Science (undesignated, major in transportation engineering) and Master of City Planning.

Multidisciplinary Programs

See Table on page 71.

Program in Engineering Graphics

The School of Civil Engineering offers two courses in engineering graphics: E.Gr. 1170 and E.Gr. 1171. E.Gr. 1170 is required in most engineering curricula; E.Gr. 1171 is acceptable as an elective in all engineering curricula. Both courses may be used as electives in many nonengineering curricula.

The objective of the two-course sequence is to teach the student the principles of graphic expression. Because much of engineering design uses graphics as a tool, this activity is prescribed early in the student's career.

Bachelor of Civil Engineering

The four-year curriculum leading to the degree Bachelor of Civil Engineering is designed to enable the graduate to enter professional practice as an engineer or to continue his or her studies in programs leading to advanced degrees in the following broad fields of specialization: construction, environmental engineering, fluid mechanics, hydraulics, hydrology, materials, sanitary engineering, soil mechanics, structures, surveying, transportation and water resources planning and management. The graduate of the B.C.E. curriculum may function in the areas of planning and design, construction, research and development, operations and maintenance. The curriculum leading to the degree Bachelor of Civil Engineering has been continuously accredited by the Engineers' Council for Professional Development since the inauguration of its accrediting program during the period 1936-38. Graduates of the B.C.E. curriculum are eligible to seek licensing as registered professional engineers.

The course requirements of the Bachelor of Civil Engineering degree are tabulated here. Many of the courses need not be taken during the quarter indicated, but prerequisites must be satisfied.

In addition to campus-wide academic re-

quirements for graduation with a bachelor's degree, the following are also required for the B.C.E. degree.

(a) The scholastic average shall be a minimum of 2.0 for those quarters during which the last 54 hours toward the degree are taken.

(b) The number of quality points earned in civil engineering courses taken toward the degree must be at least twice the number of credit hours in those courses.

(c) No more than 12 hours of free electives may be taken on a pass/fail basis. No other courses may be taken on a pass/fail basis.

Bachelor of Science

This degree may be awarded to students majoring in civil engineering whose programs meet the following criteria:

1. All campus-wide regulations pertaining to this degree must be satisfied.

2. Submit for approval a program of study which leads to a definable goal before completion of 120 quarter hours.

3. The academic quality of the program of study submitted for this degree must be equivalent to that of the B.C.E. degree.

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Chem. 1101-2 Inorganic Chemistry	4-3-5	4-3-5	.....
Econ. 2000 Economics	.....	.....	3-0-3
E.Gr. 1170 Visual Communication	2-3-3	.....	.....
Elective¹ Freshman Engineering Elective	.....	X-X-3	.....
Math. 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
Phys. 2121 Physics	.....	.....	4-3-5
Electives⁷ Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives² Free	1-0-1	1-0-1	1-0-1

Electives³

Physical Education	0-4-1	0-4-1	0-4-1
Totals	15-10-18	15-10-18	16-7-18

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
E.S.M. 2201 Statics	3-0-3	.....	.....
E.S.M. 3201 Dynamics	.....	3-0-3	.....
Math. 2307 Calculus IV	5-0-5	.....	.....
Math. 2308 Calculus V	.....	5-0-5	.....
Elective⁶ Mathematics	.....	.....	5-0-5
Phys. 2122-3 Physics	4-3-5	4-3-5	.....
E.S.M. 3301 Mechanics of Deformable Bodies	.....	.....	5-0-5
C.E. 2254 Plane Surveying	.....	.....	3-3-4
Electives⁷ Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives² Free	1-0-1	1-0-1	1-0-1
Totals	16-3-17	16-3-17	17-3-18

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
C.E. 3254 Surveying	.....	3-3-4	.....
C.E. 2502 Digital Computers	1-3-2	.....	.....
C.E. 3309 Materials of Construction	.....	3-3-4	.....
C.E. 3216 Structural Analysis I	5-3-6	.....	.....
C.E. 3053-4 Fluid Mechanics I, II	.....	3-0-3	3-3-4
Geo.S. 2100 Physical Geology	3-0-3	.....	.....
Geo.S. 2102 Physical Geology Laboratory	0-3-1

I.Sy.E. 4725

Engineering Economy	3-0-3
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M.E. 3720

Thermodynamics	4-0-4
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C.E. 4204

Metal Structural Components	3-3-4
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Electives⁷

Humanities/Social Science/Modern Language	3-0-3	3-0-3
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Electives⁴

Free	3-0-3	3-0-3
Totals	15-9-18	12-9-15	16-3-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
C.E. 3061 Fluid Mechanics Laboratory	0-3-1	.....	.....
C.E. 4214 Concrete Structural Components	3-3-4	.....	.....
C.E. 4304 Transportation Engineering I	.....	3-3-4	.....
C.E. 4103-13 Sanitary Engineering I, II	3-0-3	3-0-3	.....
C.E. 4353 Hydrology	3-0-3	.....	.....
C.E. 4154 Behavior of Soil and Rock	.....	3-3-4	.....
E.E. 3740 Electrical Instrumentation Laboratory	.....	.....	0-3-1
E.E. 3700 Elements of Electric Circuits and Instruments	.....	.....	3-0-3
Elective Either Mgt. 3260, Law I or I.Sy.E. 4090, Legal and Ethical Phases of Engineering	.....	.....	3-0-3
Electives⁷ Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3

Electives⁵

C.E.	3-0-3	3-0-3	6-0-6
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Electives⁴

Free	3-0-3
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Totals	15-6-17	15-6-17	18-3-19
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¹See College of Engineering section "Curricula and Degrees" for engineering electives.

²These free elective courses may be taken at any time during a student's course of study. Physical education courses may not be used to satisfy this requirement.

³See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

⁴Nine hours of free electives at the 3000 level or higher must be taken if advanced ROTC is not taken.

⁵C.E. electives. Each C.E. senior must choose four of the following courses: C.E. 4003, 4013, 4053, 4123, 4133, 4143, 4163, 4213, 4223, 4233, 4253, 4273, 4283, 4313, 4363, 4373, 4383, or 4774; or graduate level C.E. courses as approved by adviser and director (minimum 2.7 average required).

⁶Mathematics elective. Either Math. 2309, 3308 or 3215.

⁷See "Information for Undergraduate Students" section of this catalog for humanities, social science and modern language requirements.

Master of Science

Three degrees in this category are awarded by the School of Civil Engineering: Master of Science in Civil Engineering, Master of Science in Sanitary Engineering and the undesignated Master of Science. Common requirements for these degrees, in addition to those specified in the section "Information for Graduate Students," are listed below.

1. A minimum of 50 hours of course work is required, of which none was used to satisfy requirements for a previous degree, as approved by the student's adviser and the director.
2. Up to 15 of the 50 hours may be in 3000-4000 level courses. Courses required for the B.C.E. degree may not be used to satisfy this requirement; other 3000-4000 level courses may be used subject to the approval of the advisor and director.

3. Up to six of the 50 hours may be taken on a pass/fail basis with the approval of the adviser and director.
4. Each M.S. student is required to either (a) write an M.S. thesis and schedule at least 17 hours of C.E. 7000, or (b) write an M.S. special research problem and schedule between six and 12 hours of C.E. 8756. No more than 17 hours of C.E. 7000, nor more than 12 hours of C.E. 8756, may be counted as part of the 50 hours required for the M.S. degree.
5. Students electing to write an M.S. thesis must take at least 18 hours of course work in their major field. Students electing to write an M.S. special research problem must take at least 27 hours of course work (including C.E. 8756) in their major field.

The Master of Science in Civil Engineering degree is awarded only to students who have previously earned the B.C.E. degree or equivalent. The Master of Science in Sanitary Engineering degree is awarded only to those students who have previously earned the B.C.E. degree or who have earned an accredited bachelor's degree in engineering and have taken those undergraduate courses (for no credit toward the M.S.) required by their adviser and the director. The undesignated Master of Science degree is awarded to students not meeting the above requirements, but who have satisfied all prerequisites for the courses in their M.S. program.

A wide range of M.S. programs is available in such fields as construction, environmental engineering, fluid mechanics, hydraulics, hydrology, sanitary engineering, soil mechanics, materials, structures, transportation and water resources planning and management. Latitude in the selection of courses in an M.S. program is encouraged, provided that the resulting program leads to a definable goal.

The degrees Master of Science in Civil Engineering and Master of Science in Sanitary Engineering are accredited by the Engineers' Council for Professional Development. The undesignated Master of Science degree is not an engineering degree; holders of this degree may not be li-

censed as professional engineers, unless they have an ECPD-accredited bachelor's degree in engineering.

Graduates of technology programs are not directly admissible to graduate study in the School of Civil Engineering.

Doctor of Philosophy

The Ph.D. is the highest degree awarded and as such requires the highest level of proficiency and achievement, both in knowledge and in the performance of research presented in a written dissertation. While there are no specific course requirements, most doctoral students spend approximately two years in course work beyond the bachelor's degree while conducting their research activities plus at least another year on full-time research.

School of Electrical Engineering

Established in 1896

Director and Professor—Demetrius T. Paris; *Associate Director and Professor*—Roger P. Webb (Georgia Power Chair); *Assistant Director for Graduate Affairs and Professor*—Dale C. Ray; *Assistant Director for Undergraduate Affairs and Professor*—Thomas M. White, Jr.; *Regents' Professors*—John W. Hooper, George P. Rodrigue, Ronald W. Schafer (John O. McCarty/Audichron Chair), Kendall L. Su; *Professors*—Cecil O. Alford, Aubrey M. Bush, J. Alvin Connelly, Daniel C. Fielder, David L. Finn, Joseph L. Hammond, Jr., Vijay K. Jain (visiting), John B. Peatman, Joseph M. Pettit, Jay H. Schlag, Albert P. Sheppard, Jr., Charles R. Vail; *Associate Professors*—Thomas P. Barnwell III, William R. Callen, Jr., Atif S. Debs, Robert K. Feeney, Thomas K. Gaylord, Edward B. Joy, Edward W. Kamen, W. Marshall Leach, Jr., Russell M. Mersereau, Mohamed F. Moad, John D. Norgard, William T. Rhodes, William E. Sayle II, Glenn S. Smith, John M. Wallace, Jr.; *Assistant Professors*—T. Max Artusy, David E. Borth, Chee-Yee

Chong, David R. Hertling, Gene K. Huddleston, Athanasios P. Mellopoulos, Bruce Ramsay (visiting), Arild Thowsen, John P. Uyemura, Erik I. Verriest (visiting), Edward B. Wagstaff; *Lecturers*—William T. Anderson, Lloyd D. Bird, Allen H. Cherin, Clayton H. Griffin, Robert D. Hayes, Christopher J. M. Hodges, Terrence A. Lenahan, Jay Thomas Loadholt, M. David Prince.

General Information

Electrical engineers have pioneered the fields of electronics, computers, control, power and communication. Their work is vital in almost every sector of society. The tremendous effect of electrical engineering on society can be explained by the fact that electrical energy is the only known form of energy which can be transmitted efficiently under controlled conditions, even through a vacuum, and by means of which intelligence can be processed and transferred effectively even over extremely long distances.

The School of Electrical Engineering seeks to attract students who possess a verbal and written command of the English language, who exhibit logical thinking, creativity, curiosity, imagination, persistence, patience and who have proved their academic excellence in mathematics, chemistry and physics.

At the undergraduate level, the basic required program of instruction in fundamental theory and laboratory practice is balanced by a broad range of electives. These electives are available in a wide variety of major areas such as audio engineering, communications, computer engineering, energy engineering, instrumentation, controls and optical engineering. The student, with the counsel and guidance of faculty advisers, designs his or her electives program around his or her own special interests.

The graduate programs leading to the master's and doctoral degrees are designed to provide a broad education covering more than one specialty, followed by in-depth studies of major and minor interest areas. The doctoral program requires, in addition, concentration in a single specialty

or in a group of closely related specialties.

Graduate programs include communications, computer systems, control systems, electric power, optical engineering, electromagnetics, instrumentation, network and system theory, physical electronics and signal processing. Multidisciplinary programs in areas such as computer engineering and acoustic engineering are offered jointly with other engineering schools on campus. Full programs of courses are offered during the summer quarter, making it possible for part-time students to continue an uninterrupted program of study throughout the year.

Housed in one of the finest facilities in the world, the school maintains a vigorous program of student-centered research conducted in well equipped laboratories.

Additional information about the programs may be obtained from the *Student Handbook* or *Graduate Brochure*, available upon request, or by calling the school at (404) 894-2900. These sources of information must be consulted with respect to special rules and degree requirements by every student enrolled.

Certificate Program in Computer Engineering

Computers have become an integral part of today's society and are now used in all facets of society including scientific research, industry, business, commerce and now even the home with calculators and computer controlled appliances. With this increasing use comes an increasing demand for people who understand the design, construction, operation and application of computers. To satisfy this demand, new programs in computer engineering have been developed.

Computer engineering in the School of Electrical Engineering encompasses both traditional areas of computer engineering—the engineering of computers and engineering with computers. Engineering of computers emphasizes the design of computers and requires expertise in computational theory, digital design and computer architecture. Engineering with computers emphasizes the use of computers in engi-

neering systems and requires computer interfacing techniques, both low level and high level programming techniques and a general knowledge of computer operating systems. Both areas require an in-depth understanding of computer software at the elementary and systems level. Hence, computer engineering encompasses all aspects of design, theory and practice relating to: systems for digital and analog computation and information processing; components and circuits for computing systems; relevant portions of supporting supporting disciplines; production, testing, operation and reliability of computing systems; applications, use and programming of computing devices and information processing systems; and the use of computers in electrical and electronic engineering.

Those undergraduate engineering students who specialize in the area of Computer Engineering will be awarded a Certificate in Computer Engineering. To qualify for this certificate, a student must complete all requirements for an ECPD-accredited bachelor's degree in an engineering discipline and, in addition, must successfully complete, with a grade of C or better, the following nine elective courses, totaling 30 quarter hours: EE 1010, EE 3032, EE 3033, EE3034, EE4075, EE4077, EE4080, ICS 3422, and Math 2020. None of these courses are to be required by title and number for the bachelor's degree in the student's major field. Non-electrical engineering students may substitute EE3360 for one of the EE courses listed in the program.

Further details may be obtained by directly contacting the School of Electrical Engineering.

Multidisciplinary Programs

See table on page 71.

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Electives¹	.....	3-0-3	3-0-3
Electives²			
Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3

Elective

Any one of the freshman engineering electives⁵

Math. 1307-8-9

Calculus I, II, III

Phys. 2121

Particle Dynamics

Chem. 1101-2

General Chemistry

Electives³

Physical Education

Totals

Sophomore Year

Course

1st Q.

2nd Q.

3rd Q.

Electives¹

Electives²

Humanities/Social Science/Modern Language

E.S.M. 2201

Statics

E.S.M. 3201

Dynamics I

Math. 2307

Calculus IV

Math. 2308

Calculus V

Math. 3308

Differential Equations

Phys. 2122

Electromagnetism

Phys. 2123

Optics and Modern Physics

E.E.⁴ 3200-50

Elements of Electrical Engineering

E.E. 3400

Instrumentation Laboratory

Totals

Junior Year

Course

1st Q.

2nd Q.

3rd Q.

Electives¹

Electives²

Humanities/Social Science/Modern Language

E.E. 3300-10-20

Electromagnetics

E.E. 3210-20

Circuits and Systems

E.E. 3215

Signals and Systems

E.E. 3260

Engineering Electronics

E.E. 3270

Nonlinear Devices and Circuits

E.E. 3330

Electromechanical Systems and Energy Conversion

E.E. 3360

Digital Hardware

E.E. 3411-21-31

Junior E.E. Laboratory I, II, III

Totals

Senior Year

Course

1st Q.

2nd Q.

3rd Q.

Electives¹

Electives²

Humanities/Social Science/Modern Language

E.E. 4350

Materials Science

E.E. 4411-21

Senior E.E. Laboratory I, II

E.E. 4430

Project Laboratory

Totals

¹Electives: The electrical engineering curriculum contains 57 hours of electives, in addition to 2 hours of specified physical education electives and 36 hours of specified humanities/social science/modern language electives.

The 57 hours of electives must include a minimum of:

3 hours of freshman engineering electives.

See "Curricula and Degrees," College of Engineering.

3 hours of junior-level or senior-level course work in written or verbal communication of ideas which may be one of the following English courses: Engl. 3015, Engl. 3023, Engl. 3024.

12 hours of technical electives subject to school approval. Generally, the technical electives are junior or senior engineering (not E.E.), mathematics, or natural science courses. These electives must include one of the following five thermodynamics options: (1) M.E. 3720 (2) M.E. 3726 (3) M.E. 3322 and M.E. 3323 (4) Phys. 3141 or (5) a course or courses approved by the School of Electrical Engineering. In addition, one course in graphics is strongly recommended.

18 hours of electrical engineering electives, subject to school approval. These electives must include one of the following seven courses in applied probability: (1) E.E. 3340 (2) Phys. 3145 (3) I.Sy.E. 3027 (4) Biol. 3333 (5) Math. 3710 (6) Math. 3215 or (7) Math. 4215. E.E. 3340 will apply toward satisfying the E.E. elective course requirements; all other courses will apply toward satisfying the technical breadth requirement for the bachelor's degree in electrical engineering.

21 hours of free electives. These free electives may be taken at any time during a student's course of study. Up to six hours of basic ROTC and a maximum of nine hours of advanced ROTC may be used for elective credit in the program.

²Three credit hours each of literature, history and political science must be included. One year of freshman English is strongly recommended. Additional humanities/social science/modern language electives and their required distribution are given in "Information for Undergraduate Students," Academic Regulations.

³See "Information for Undergraduate Students," Academic Regulations, for physical education requirements for both men and women.

⁴It is expected that each student, through independent study, attendance at seminars or formal courses, will acquire the ability to program simple problems on one of the digital computers available on campus prior to enrollment in E.E. 3200.

⁵See "Curricula and Degrees," College of Engineering, for a listing of freshman engineering electives.

Additional degree requirements: all students are required by the University System of Georgia to take certain examinations in Constitution and history, in English proficiency and in their respective major areas. These examinations are described under Academic Regulations, "Information for Undergraduate Students."

School of Engineering Science and Mechanics

Established in 1959

Director and Professor—Milton E. Raville; *Associate Director and Professor*—Wilton W. King; *Regents' Professor*—Andrew W. Marris; *Professors*—William J. Lnenicka, David J. McGill, George M. Rentzepis, George J. Simitzes, Charles E. S. Ueng, James T. S. Wang, Gerald A. Wempner; *Associate Professors*—Jerry M. Anderson, Donald G. Berghaus, Michael C. Bernard, Robert W. Shreeves, Hyland Y. L. Chen, John C. Clark, Raymond P. Vito, Wan-Lee Yin; *Assistant Professors*—William A. Johnston, Arthur J. Koblasz, Richard K. Kunz, John G. Papastavridis, Donald L. Vawter.

General Information

The School of Engineering Science and Mechanics administers the undergraduate curriculum leading to the degree of Bachelor of Engineering Science and Mechanics and graduate programs leading to the degrees of Master of Science, Master of Science in Engineering Science and Mechanics and Doctor of Philosophy.

The primary objective of the undergraduate curriculum is to prepare students for careers in engineering and related fields emphasizing the fundamental principles and techniques of mathematics and the engineering sciences—solid mechanics, fluid mechanics, materials science, electrical sciences, heat transfer and thermodynamics. The curriculum, totaling 205 credit hours, provides for 82 hours of elective credit, including 16 hours of free electives, 30 hours of technical electives and 33 hours of humanities/social science/modern language electives. The engineering science and mechanics curriculum is considered particularly well suited for the above average student whose specific goals within the general framework of engineering and the physical sciences have not yet been formulated.

Elective options provide in-depth study in interdisciplinary, technically-related areas

as well as preparation for professional schools of business, law and medicine. Thus, the engineering science and mechanics graduate has a wide choice of specialized areas that can provide a foundation for starting his or her career or for further study.

Graduate study and research in the School of Engineering Science and Mechanics includes work in modern continuum mechanics, stress analysis, stability, structures, dynamics, vibrations, space mechanics, fracture mechanics, finite element methods and other computational techniques, fluid mechanics, biomechanics, acoustics, wave propagation, applied stochastic processes, optimization techniques, materials science and experimental stress analysis. A wide variety of related graduate courses is also available to the E.S.M. graduate student in the other schools of the institute. Flexibility and interdisciplinary interests are encouraged in the planning of individual programs of study.

The faculty members of the School of Engineering Science and Mechanics hold degrees in most of the recognized branches of engineering, as well as mathematics and physics. Housed in two buildings, E.S.M. has excellent classroom, office and shop facilities and modern, newly-equipped laboratories. Various grants, assistantships and fellowships are available to students of outstanding merit.

Multidisciplinary Programs

See table on page 71.

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Electives¹			
Engineering	X-X-3	.....	.....
Chem. 1101-2			
Inorganic Chemistry	4-3-5	4-3-5	.....
E.Gr. 1170			
Visual Communication and Engineering Design I	.....	2-3-3	.....
Math. 1307-8-9			
Calculus I, II, III	5-0-5	5-0-5	5-0-5
Phys. 2121			
Physics	.....	.....	4-3-5

Electives

Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives²			
Free	.....	.....	3-0-3
Electives³			
Physical Education	0-4-1	0-4-1	0-4-1
Totals	12-7-17	14-10-17	15-7-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
E.S.M. 2101-2			
Engineering Design I, II	0-3-1	0-6-2	.....
E.S.M. 2201			
Statics	3-0-3	.....	.....
E.S.M. 3201-2			
Dynamics I, II	.....	3-0-3	3-0-3
E.E. 3200			
Elements of Electrical Engineering	.....	.....	3-0-3
Math. 2307			
Calculus IV	5-0-5	.....	.....
Math. 2308			
Calculus and Linear Algebra	.....	5-0-5	.....
Math 2309 or 3308			
Differential Equations	.....	.....	5-0-5
Phys. 2122-3			
Physics	4-3-5	4-3-5	.....
Electives			
Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Elective²			
Free	.....	.....	3-0-3
Totals	15-6-17	15-9-18	17-0-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
E.S.M. 3111			
Experimental Methods in Engr. Science	.....	.....	2-3-3
E.S.M. 3301			
Mechanics of Deformable Bodies	5-0-5	.....	.....
E.S.M. 3302			
Mechanics of Materials	.....	3-0-3	.....

E.S.M. 3501 Fluid Mechanics	.....	5-0-5	
E.S.M. 4210 Mechanical Vibrations	.....	3-0-3	
E.E. 3250 Elements of Electrical Engineering	3-0-3	.....
E.E. 3400 Instrumentation Laboratory	.....	1-3-2	.....
Engl. 3023 Written Communication in Science, Business and Industry	3-0-3	.....
M.E. 3322 Thermodynamics	3-0-3	.....
M.E. 3323 Thermodynamics	.....	3-0-3	.....
M.E. 3342 Transport Phenomena I	.....	.....	3-0-3
Elective³ Mathematics	.....	3-0-3	.....
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	.....
Electives Free	.....	3-0-3	3-0-3
Totals	17-0-17	16-3-17	16-3-17

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
E.S.M. 3451 Computer Applications in Engineering Science & Mechanics	3-0-3	.....	.....
E.S.M. 4122-3 Projects in Engineering Science	0-3-1	0-6-2	.....
Econ. 2000 Survey of Principles of Economics	3-0-3	.....	.....
Met. 3301 Engineering Materials	4-3-5	.....	.....
Elective Either I.Sy.E. 4000, Introduction to Systems Theory, or M.E. 4445, Automatic Control	.....	.....	3-0-3

Elective³ Mathematics	.....	3-0-3	.....
Elective⁴ Physics	.....	3-0-3	.....
Electives Technical	3-0-3	6-0-6	6-0-6
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives⁵ Free	.....	.....	4-0-4
Totals	16-6-18	15-6-17	16-0-16

* At least six hours of electives must be in the area of design, synthesis or systems.

¹ See College of Engineering section, "Curricula and Degrees" for engineering electives.

² These free elective hours may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, then it should be scheduled beginning at the first quarter the student is enrolled. A maximum of nine hours of free electives in junior and senior years may be in advanced ROTC.

³ To be selected from Math. 3110, 4215, 4320, 4581, 4582.

⁴ To be selected from Phys. 3138, 3143, or 3751. If Phys. 3138 or 3143 is chosen, the extra two credits will be used as technical electives.

⁵ At least six hours of electives must be in the area of design, synthesis or systems.

⁶ See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

School of Health Systems

Established in 1977,
program in 1972,
option in 1958

Director and Regents' Professor—Harold E. Smalley; *Associate Professor*—Justin A. Myrick; *Assistant Professors*—Thomas H. Bowlin, Bonnie J. Kay; *Lecturers*—Howard E. Fagin, Julian V. Pittman, Nelson F. Sayford, Charles Y. Thomason III; *Adjunct Faculty*—Richard M. Bramblett, Daniel P. Golightly, James B. Mathews; *Senior Research Associate*—Felicenne H. Ramey; *Research Scientist*—Darlene Kishbaugh;

Research Associate—Ann A. Bailey; *Fulbright-Hays Scholar*—Carlos M. Quesada.

General Information

Health Systems is that field of study and practice aimed toward improving the delivery of health care services through the application of systems science and management engineering. Emphasis is upon systematic planning, engineering design and scientific management in respect to health care facilities, manpower and methods. Because of the complexity of health care management problems, the body of knowledge that has come to be known as health systems builds upon and draws from other branches of engineering, computer technology, management science, architecture, behavioral science and the various health professions. Health systems is an allied health field grounded in the engineering profession.

A career in this field is challenging and rewarding in many ways. Health care is humanitarian and health services are important to society; the industry is large, expensive and in need of improvement. A career in health systems is an opportunity to use modern scientific methods in the performance of a vital public service.

Health systems specialists are in short supply and there are many job openings with hospitals, nursing homes, doctors' offices, government agencies, universities, medical centers, research and planning organizations, manufacturers of hospital equipment, health insurance companies, management consultants, architectural firms and construction contractors.

The School of Health Systems is an academic division of Georgia Tech's College of Engineering and it is affiliated with the Medical College of Georgia. The school has extensive programs of education, research and service, and through the Health Systems Research Center, it engages in interdisciplinary and interinstitutional research, continuing education and community outreach activities.

Programs of the school are a direct outgrowth of faculty involvement in this field since 1952 and of a health-related aca-

demic program begun at Georgia Tech in 1958. The school has been admitted to institutional membership in the Georgia Hospital Association and the American Hospital Association, the American Society of Allied Health Professions, the American Health Planning Association and the Association of University Programs in Health Administration. Close working relationships are also maintained with the Hospital Management Systems Society and with the Health Services Division of the American Institute of Industrial Engineers.

B.S.H.S. Curriculum

The undergraduate program was designed to prepare students for professional careers in the field of health systems and it provides an academically sound base for lifelong learning. Even though it is technical and analytical, the program of study places some emphasis upon interpersonal, organizational and societal relationships. And, although it is directed toward the health field, the program provides students with valuable knowledge and marketable skills needed in many different fields.

The curriculum enables students to keep their options open for a variety of positions in the health field. It provides considerable flexibility so that students from various fields can transfer into it without losing credit already earned. It contains sufficient electives to accommodate several specialty interests, including health systems analysis, health systems planning and premedical preparation. Modified versions of this curriculum are available under the dual degree (3-2) program.

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Chem. 1101-2 General Chemistry	...	5	5
E.Gr. 1170 Engineering Graphics	3	...	...
Math. 1307-8-9 Calculus	5	5	5
Pol.¹ 1251 Government of the U.S. ²	...	3	...

Elective¹			
Hist. 1001 or 2, History of the U.S. ²	3	...	...
Electives³			
Humanities	3	3	3
Electives⁴			
Physical Education	1	1	1
Electives⁵			
Free	3	...	3
Totals	18	17	17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Econ.¹ 2000-1			
Economic Principles	3	3	...
H.S. 2011			
The Health Field	...	...	3
I.Sy.E. 3027			
Probability	...	3	...
I.Sy.E. 3028			
Engineering Statistics I	...	...	3
Math. 2010			
Finite Mathematics	5	...	...
Phys. 2121-2-3			
Engineering Physics	5	5	5
Elective			
E.E. 1010 or I.C.S. 1700, Computer Programming	...	3	...
Electives³			
Humanities	3	3	3
Elective¹			
Social Science	...	...	3
Totals	16	17	17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
Engl. 3023			
Written Communications	...	3	...
H.S. 3011			
Hospital Functions	3	...	...
H.S. 3021			
Nonhospital Components	...	3	...
H.S. 3115-6			
Management Engineering I, II	4	3	...

H.S. 3117-8			
Management Engineering III, IV	...	3	3
H.S. 3211			
Data Processing	...	...	3
H.S. 3351			
Projects and Reports	...	...	3
I.Sy.E. 3029			
Engineering Statistics II	3	...	...
I.Sy.E. 3131			
Operations Research	...	3	...
I.Sy.E. 4101			
Operations Planning	...	...	4
Mgt. 3700			
Analysis of Financial Data	4	...	...
Electives⁵			
Free	3	3	3
Totals	17	18	16

Senior Year⁶

Course No.	Subject	Credit Hrs.
H.S. 4351	Case Studies	3
H.S. 4570	Field Training Proposal	1
H.S. 4571-2-3	Senior Externship	12
H.S. 4693	Seminar	1
I.Sy.E. 3025	Engineering Economy	3
Psy. 3033 ¹	General Psychology	3
Elective ⁶	Health Systems	3
Electives ⁷	Environmental	6
Electives ⁸	Technical	6
Electives ⁵	Free	5
Senior-year Total		43
Total Degree Requirements		196

¹These courses apply toward satisfaction of the 18-hour social science requirement stated in "Information for Undergraduate Students."

²Either Pol. 1251 or 3200 gives exemption from the U.S. and Georgia constitution examination and any one of Hist. 1001, 1002, 3010 or 3011 gives exemption from the U.S. and Georgia history examination. Students electing the examinations must substitute six hours of approved social science electives.

³Approved humanities courses are listed in "Information for Undergraduate Students." The 18 hours of humanities must include at least three hours of literature and the student should plan these and other electives with a view toward satisfying the rising junior English examination.

⁴See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman

physical education requirements for both men and women.

⁵A list of recommended electives is available upon request. Free elective hours may include credit for P.E. and/or ROTC courses up to the maximums stated in "Information for Undergraduate Students."

⁶The student may choose any course with the H.S. prefix or a substitute course approved by the faculty.

⁷These are courses that describe the health field, medical affairs, the life sciences, the community or other aspects of the environment in which the graduate will practice and are to be selected from among courses approved by the faculty.

⁸These are courses that emphasize principles and techniques useful in analyzing or improving management systems and are to be selected from among courses approved by the faculty.

⁹Check the official school bulletin board for the quarters in which senior-year courses are expected to be offered.

Health Planning Option

The health planning option is provided in order to broaden the preparation of the health systems specialist for professional practice in the subspecialty of health systems planning. Such a planning function covers manpower, facilities, logistics, organization, finances and other system components. It includes consideration of medical, behavioral, socioeconomic, demographic, ethnic, political, legal and other environmental factors. Some health systems planners serve in government agencies, consulting firms or other organizations concerned with multi-institutional and community-wide systems of health care delivery. Others perform planning functions within management engineering departments of individual hospitals, clinics or other health care institutions.

Health systems majors may emphasize health systems planning by utilizing their electives to include courses appropriate to the planning function. Such students should make their selections from the following categories:

Environmental Electives	
Mgt. 4290, Pol. 3217, 3220, 3221, 3250,	
Soc. 3310	3

Econ. 3501, 4310, 4330, 4331,	
H.S. 3332	3
Health Systems Elective	
H.S. 4021	3
Social Science Elective	
Soc. 1376	3
Technical Electives	
I.Sy.E. 4028, 4044, 4157, I.C.S. 4334	3
H.S. 3341	3
Free Electives	
C.P. 1100, H.S. 3780	3
I.Sy.E. 4053, 4056	3
Health Planning Courses	24
Remaining Free Electives	14

Premedical Option

The premedical option was designed to satisfy the normal course preparation required by most medical and dental schools while providing the systems orientation now being favored by leading medical educators.

Nationally, about two of every three medical school applicants are rejected and the proportion for professed premeds still in undergraduate school is even higher. A significant advantage of this premedical option is that, if the student decides not to apply to medical or dental school or applies and is not admitted, he or she will be prepared to pursue an alternative health career.

Under this premedical option, health systems majors satisfy all required courses of the B.S.H.S. curriculum and utilize their electives to include the key premed courses. Thus the graduate is fully qualified as a health systems specialist and is prepared for medical or dental school.

This option concentrates the premed courses in the freshman and sophomore years so as to gain the advantage of submitting the medical or dental school application early in the junior year. Therefore, a decision to elect this option should be made prior to or early in the freshman year.

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Chem.¹ 1111-2 General Chemistry	5	5	...
Chem. 2113 Chemical Principles	...	...	4
E.Gr. 1170 Engineering Graphics	3	...	...
Engl.² 1001-2-3 Analysis of Literature	3	3	3
H.S. 2011 The Health Field	...	...	3
Math. 1307-8-9 Calculus	5	5	5
Elective E.E. 1010 or I.C.S. 1700, Computer Programming	...	3	...
Elective³ Physical Education	1	1	1
Totals	17	17	16

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Biol. 2210-1-2 Principles of Biology	5	5	5
Chem. 3311-2-3 Organic Chemistry	3	3	3
Chem. 3381-2 Organic Chemistry Laboratory	...	2	2
I.Sy.E. 3027 Probability	...	3	...
I.Sy.E. 3028 Engineering Statis- tics I	...	...	3
Phys. 2121-2-3 Engineering Physics	5	5	5
Psy.⁴ 3303 General Psychol- ogy A	3	...	...
Totals	16	18	18

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
Econ.⁴ 2000 Economic Principles	3

Engl. 3023

Written Communica- tions	...	3	...
H.S. 3011 Hospital Functions	3	...	...
H.S. 3021 Nonhospital Compo- nents	...	3	...
H.S. 3115 Management Engi- neering I, II	4	3	...
H.S. 3117-8 Management Engi- neering III, IV	...	3	3
H.S. 3211 Data Processing	...	...	3
H.S. 3351 Projects and Reports	...	...	3
I.Sy.E. 3029 Engineering Statis- tics II	3	...	...
Mgt. 3700 Analysis of Financial Data	4	...	...
Math. 2010 Finite Mathematics	...	5	...
Psy.⁴ 3304 General Psycho- logy B	3	...	...
Elective² Humanities	...	...	3
Totals	17	17	15

Senior Year

Course No.	Subject	Credit H.
Econ. 2001 ⁴	Economic Principles	
H.S. 4351	Case Studies	
H.S. 4570	Field Training Proposal	
H.S. 4571-2-3	Senior Externship	
H.S. 4693	Seminar	
I.Sy.E. 3025	Engineering Economy	
I.Sy.E. 3131	Operations Research	
I.Sy.E. 4101	Operations Planning	
Pol. ⁴ 3200	American Constitutional Problems ⁵	
Elective ⁶	Health Systems	
Elective ⁴	Hist. 3010 or 1, History of the U.S. ⁵	
Electives ²	Humanities	
	Senior-year Total	

Total Degree Requirements

¹ The Chem. 1111-2, 2113 series is designed for students with good preparation in high school chemistry. It is recommended that students in doubt start with the Chem. 1101-2 series and switch to Chem. 1112 or to 2113 if good grades are made in Chem. 1101-2.

² These courses apply toward satisfaction of the 18-hour humanities requirement stated in "Information for Undergraduate Students."

³ See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

⁴ These courses apply toward satisfaction of the 18-hour social science requirement stated in "Information for Undergraduate Students."

⁵ Any one of Hist. 1001, 1002, 3010 or 3011 gives exemption from the U.S. and Georgia history examination and either Pol. 1251 or 3200 gives exemption from the U.S. and Georgia constitution examination. Students electing the examinations must substitute six hours of approved social science electives.

⁶ The student may choose any course with the H.S. prefix or a substitute course approved by the faculty.

⁷ A list of recommended electives is available upon request. Free elective hours may include credit for P.E. and/or ROTC courses up to the maximums stated in "Information for Undergraduate Students."

⁸ Check the official school bulletin board for the quarters in which senior-year courses are expected to be offered.

The Master's Degree

The School of Health Systems offers graduate courses and administers programs of study leading to the degree Master of Science in Health Systems (M.S.H.S.). The general purpose of the M.S.H.S. curriculum is to provide an academically sound, socially relevant educational experience which will prepare graduate students for professional careers concerned with the analysis and planning of institutional and community-wide systems of health care delivery as a means of improving the health care system.

Practitioners in this field may specialize in either health systems *analysis* or health systems *planning*, but they are competent to practice in both subspecialties. Analysts normally are employed or are retained as consultants by individual hospitals or other health care institutions. Planners typically

serve in government agencies, consulting firms or other organizations concerned with multi-institutional and community-wide systems of health care delivery.

The M.S.H.S. curriculum includes a series of lecture, seminar, case study and project-oriented courses, with specialty-area electives, field training, career placement assistance and alumni communications. The graduate student may elect either an analysis option or planning option, each requiring four to six academic quarters depending upon the nature of previous experience and course work preparation.

Admission requirements include a bachelor's degree from a recognized institution, with a major in a scientific field (such as engineering, mathematics, statistics, computer science, physical science, social science or management science), a good academic record, a quantitative and analytical orientation, a year of calculus and an interest in the health field. If prerequisite courses in math, statistics or operations research are anticipated, the applicant should plan to begin the program of study in the spring or summer, otherwise in the fall quarter. However, applications for full-time or part-time study will be considered for initial enrollment in any of the four academic quarters which begin in September, January, March and June.

Financial support for M.S.H.S. students is often available through scholarships, fellowships, assistantships, sponsored externships, work-study programs, part-time employment with cooperating health institutions or agencies, student loans and other financial aid programs. Nonresident tuition may be waived for residents of Arkansas, Louisiana, Tennessee and West Virginia, under the SREB Common Market, and for residents of other states on a competitive basis. There is no application fee.

Doctoral Degree Opportunities

Health related graduate work leading to the Doctor of Philosophy degree is available through any one of several Georgia Tech schools authorized to offer the doctorate, for example, the School of Industrial and Systems Engineering, the School of Infor-

mation and Computer Science or the College of Management. A health systems component may be arranged under a special interdepartmental program in which the School of Health Systems cooperates. A student interested in such an arrangement should obtain approval of his or her major school, then contact the director, School of Health Systems.

School of Industrial and Systems Engineering

Established in 1945, option in M.E., 1924-1945

Director—Michael E. Thomas, Frank F. Groseclose (Emeritus); *Associate Director for Undergraduate Programs*—Nelson K. Rogers; *Associate Director for Graduate Programs*—William W. Hines; *Professors*—Mokhtar S. Bazarra, Leslie G. Callahan, Stuart J. Deutsch, Paul T. Eaton (Emeritus), Augustine O. Esogbue, David E. Fyffe, John J. Jarvis, Robert G. Jeroslow (Adjunct), Cecil G. Johnson, Lynwood A. Johnson, Patrick D. Krolak, Shaul P. Ladany, Robert N. Lehrer, Douglas C. Montgomery, H. Donald Ratliff, C. M. Shetty, Matthew J. Sobel (Adjunct), Rocker T. Staton, Gerald J. Thuesen, Harrison M. Wadsworth, Jr., John A. White, Jr.; *Associate Professors*—Jerry Banks, Terence Connolly, Willard R. Fey, Russell G. Heikes, Robert G. Parker, Alan L. Porter, Ronald L. Rardin, Frank E. Roper, Thomas L. Sadosky, Donovan B. Young; *Assistant Professors*—John S. Carson, II, Leon F. McGinnis, Gunter P. Sharp, Barbaros C. Tansel; *Lecturers*—Edward H. Ely, Harry C. Gregory, William H. Moll, Phillip E. Pfeifer, Jack R. Walker.

General Information

Industrial and systems engineering provides both a basic engineering foundation and a grounding in the interactions between technology and management. Students in the program are usually interested in obtaining a fundamental engineering background as the basis for professional

specialization in activities associated with the field—operations research, management science, systems engineering, methods, organization, planning—or as preparation for other endeavors, such as management or as a foundation for law, medicine or other pursuits. The study of industrial and systems engineering places emphasis upon developing the student's abilities to analyze and design systems that integrate technical, economic and social-behavioral factors in industrial, service, social and government organizations. The degree program offered is the Bachelor of Industrial Engineering (B.I.E.).

B.I.E.

The principal strength of the program leading to the Bachelor of Industrial Engineering degree lies in a solid, well-coordinated core of courses in systems analysis and systems design, which relies heavily upon the engineering sciences, basic sciences and social sciences. Elective hours make the program flexible as does the senior year design sequence, which permits a student to gain experience in design activities in manufacturing, service or government industries. The broad spectrum of required course work associated with the design sequence qualifies the student to perform in operations and facilities, management information and controls, and systems engineering environments.

Options for Exceptional Students

An option program is available to encourage students with superior abilities to fully avail themselves of a range of unusual educational opportunities.

Participation in these programs requires demonstrated scholastic excellence, prior arrangements with the student's adviser and provides the following options, individually or in combination.

Graduate level courses in lieu of senior year electives

Students with a cumulative grade-point average of 3.3 or above may schedule up to 9 credit hours of approved graduate level

courses. These credits, when approved by the student's adviser, may be made available for subsequent credit toward a graduate degree.

Accelerated study

Students with a 3.3 or above average during the three preceding quarters (including at least 45 credits), may complete course requirements for any nonproject industrial and systems engineering course at their own pace by self study with counseling and guidance by the course instructor. Students may register for any number of courses but must satisfy instructor and course examination requirements. Class attendance is not required. Arrangements must be made with course instructors prior to the start of the quarter.

Individual project and research work

Students with a 3.0 or above average during the preceding three quarters (including at least 45 credits) may schedule up to 12 credits of project or research work or both, done in collaboration with the faculty or advanced graduate students, which may be substituted for senior-year electives. Students with less than 3.0 average are limited to six credits of such project or research work.

Governor's intern program

I.Sy.E. seniors enrolled in the governor's intern program may receive six hours of design credit (4104-5) and six hours of I.Sy.E. elective credit for participation in the program.

Visiting Scholar/Practitioner Offerings

Upon occasion, the school brings to campus selected individuals of unique accomplishment for course offerings built around their special areas of activity, thus making available a broader range of course materials than regularly provided. The typical schedule is Friday afternoon and evening instruction four times during the quarter.

Graduate Programs

The School of Industrial and Systems Engineering offers graduate programs leading

to the degrees Master of Science in Industrial Engineering, Master of Science, Master of Science in Operations Research and Doctor of Philosophy.

The M.S.I.E. program is available for students holding the B.I.E. degree and for other engineers who satisfy requisites covering the principal subject matter of the current B.I.E. curriculum. The M.S.O.R. program is available for students holding the B.S. in engineering, mathematics or science. Requisites include work in probability, statistics, engineering economy, linear algebra, advanced calculus and optimization. These requirements may be satisfied after enrollment; however, such course work may not be applied to satisfy degree requirements.

The undesignated M.S. is intended for those students who desire to follow programs in applied statistics, systems analysis, ergonomics and human engineering, industrialization or other special programs. Prerequisites are the same as for the M.S.O.R. program.

Except for the industrialization program, a student has two options: either 33 quarter hours of course work and a thesis or 50 quarter hours of course work and a written comprehensive examination. The industrialization program requires either 43 quarter hours of course work and a thesis or 60 quarter hours of course work and a written comprehensive examination.

The doctoral program is intended for highly gifted individuals for whom past accomplishments and evaluations indicate a high potential for successful completion of the program requirements and a subsequent creative contribution to the field. Admission is, therefore, dependent upon student qualification rather than educational background in any specified discipline.

All degree curricula of the school are offered on a 12-month basis. Graduate programs may be started in any quarter.

Financial aid is available in the form of traineeships, fellowships and research assistantships.

Multidisciplinary Programs
See table on page 71.

The B.I.E. Curriculum

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Engl. 1001-2-3⁶ Introduction to Literature	3-0-3	3-0-3	3-0-3
Chem. 1101-2 General Chemistry	4-3-5	4-3-5	.....
Math. 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
E.Gr. 1170 Visual Communication and Engineering Design I	2-3-3	.....	.....
Elective⁴ Engineering	.....	X-X-3	.....
Phys. 2121 Particle Dynamics	.....	.....	4-3-5
Electives¹ Physical Education	0-4-1	0-4-1	0-4-1
Elective² Social Science	.....	.....	3-0-3
Totals	14-10-17	14-10-17	15-7-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Phys. 2122 Electromagnetism	4-3-5	.....	.....
Phys. 2123 Optics and Modern Physics	.....	4-3-5	.....
E.S.M. 2201 Statics	.....	.....	3-0-3
Math. 2307-8 Calculus IV, V	5-0-5	5-0-5	.....
Electives³ Humanities	3-0-3	3-0-3	3-0-3
Econ. 2000-1 Principles of Economics	3-0-3	3-0-3	.....
Mgt. 3700⁵ Analysis of Financial Data	.....	.....	4-0-4
I.C.S. 1700 Digital Computer Organization and Programming	.....	3-0-3	.....

I.Sy.E. 3027
Applications of Probability

Math. 3709
Math for Systems Engineering

Elective²
Social Science

Totals

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
E.S.M. 3201 Dynamics I	3-0-3	.....	.....
E.S.M. 3301 Mechanics of Deformable Bodies	.....	5-0-5	.....
M.E. 3720 Thermodynamics	.....	.....	4-0-4
I.Sy.E. 3028-9 Engineering Statistics I, II	3-0-3	3-0-3	.....
I.Sy.E. 3105 Organizational Structures	3-0-3	.....	.....
I.Sy.E. 3025 Engineering Economy	3-0-3	.....	.....
I.Sy.E. 3010 Man-Machine Systems	.....	3-0-3	.....
I.Sy.E. 3115 Industrial and Systems Engineering Measurements	.....	.....	3-0-3
I.Sy.E. 3260 Introduction to Systems Engineering	3-0-3	.....	.....
I.Sy.E. 3131-2 Operations Research I, II	.....	3-0-3	3-0-3
I.Sy.E. 4044 Simulation	.....	.....	2-3-3
I.Sy.E. 3100 The Professional Practice of Industrial and Systems Engineering	.....	.....	0-3-1

Engl. 3015

Public Speaking

Engl. 3023

Written Communication in Science, Business and Industry

Elective
Free

Totals

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
E.E. 3700 Elements of Electric Circuits and Instruments	3-0-3	.....	.....
I.Sy.E. 4101 Operations Planning and Scheduling	3-3-4	.....	.....
I.Sy.E. 4102 Operations and Facilities Design	3-3-4	.....	.....
I.Sy.E. 4103 Management Information and Control Systems	.....	3-0-3	.....
I.Sy.E. 4104-5 I.Sy.E. Design I, II	.....	0-9-3	0-9-3
I.Sy.E. 4039 Quality Control	3-0-3	.....	.....
Electives I.Sy.E.	.....	6-0-6	6-0-6
Electives² Social Science	.....	3-0-3	3-0-3
Electives Free	3-0-3	.....	3-0-3
Totals	15-6-17	12-9-15	12-9-15

¹ See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

² Social Science Electives must include three hours of U.S. History, three hours of U.S. Government, and six credit hours of Social Science.

³ See "Information for Undergraduate Students" for humanities electives to satisfy the College of Engineering requirements.

⁴ See College of Engineering section "Curricula and Degrees" for freshman engineering electives.

⁵ Mgt. 2000 and Mgt. 2001 may be substituted for Mgt. 3700 plus two hours of free electives.

School of Mechanical Engineering

Established in 1888

Director and Professor—S. Peter Kezios; *Professor and Vice-chancellor for Research*—M. J. Goglia; *Regents' Professor*—Allan D. Pierce; *Professors*—S. C. Barnett, John Berry, W. Z. Black, Gene T. Colwell, *S. L. Dickerson, P. Durbetaki, Jerry H. Ginsberg, *A. V. Larson, S. Ramalingam, J. Richard Williams, Ward O. Winer; *Associate Professors*—W. J. Book, M. R. Corley, P. V. Desai, H. L. Johnson, P. V. Kadaba, S. V. Shelton; *Assistant Professors*—R. B. Evans, R. T. Gibbs, W. James Hadden, Jr., J. G. Hartley, C. H. Jacobs, S. M. Jeter, L. D. Koffman, W. J. Wepfer, W. M. Williams, P. J. Yoder; *Instructor*—C. W. Meyers; *Lecturers*—J. W. Brazell, David Kalish; *Research Engineer*—Scott S. Bair.
* Associate Directors

General Information

Mechanical engineering continues to be one of the most viable engineering disciplines. It traditionally deals with the largest diversity of engineering problems. This general nature of mechanical engineering allows a number of multidisciplinary activities to be comfortably organized under it.

Mechanical engineering embraces the generation, conversion, transmission and utilization of thermal and mechanical energy, the design and production of tools and machines and their products, the consideration of fundamental characteristics of materials as applied to design and the synthesis and analysis of mechanical, thermal and fluid systems, including feedback and control. Design, production, operation, administration, economics and research are functional aspects of mechanical engineering.

The undergraduate curriculum covers the fundamental aspects of the field, em-

⁶ Freshmen who waive English 1001, 1002, or 1003 as a result of English Department Placement Tests may substitute 2000 level or higher English courses which qualify as Humanities.

phasizes basic principles and educates the student in the use of these principles to reach optimal design solutions for engineering situations and problems. Specific design subject matter and materials are also drawn from such engineering activities as solar energy and biomechanical systems, as well as from the more traditional areas.

Emphasis in the freshman and sophomore years is on mathematics, chemistry and physics. In the junior and senior years on the strength of materials and metallurgy, applied mechanics, thermodynamics, heat transfer, fluid mechanics, systems and controls, thermal and mechanical processing, design and the application of fundamental subjects to the diverse problems of mechanical engineering are stressed. Nevertheless, it is possible to experience aspects of creative decisions and designs at the freshman level. Laboratory work and design projects are stressed.

Satisfactory completion of the curriculum leads to the degree Bachelor of Mechanical Engineering.

Optional Programs

While the curriculum is structured to meet the general educational goals of the majority of mechanical engineering students, the school regularly considers and approves major modifications of the basic program to allow a student with certain well defined educational objectives to pursue minor fields within the school or within Georgia Tech while earning a degree in mechanical engineering. In this way a student may achieve his or her basic degree in mechanical engineering while specializing in any one of a large number of other fields. Aside from the broad flexibility afforded by such special programs, a student following the regular M.E. curriculum takes a number of electives as well as special problems and projects, all of which allow latitude in pursuing his or her educational goals and special interests.

Graduate Programs

The School of Mechanical Engineering has a rapidly expanding and vigorous graduate

program of advanced study and research in the areas of acoustics and noise control, automatic controls, bioengineering, combustion, complex systems design, controlled machine tools, dynamics and vibration, energy engineering, engineering design, environmental quality control, flammability, fluid mechanics, fluidics and fluid power, heat transfer, lubrication, magnetogas dynamics and plasma, manufacturing engineering, materials processing, materials science, mechanisms (synthesis and analysis), nuclear power, solar power, vehicle propulsion, thermal systems (analysis and design), thermodynamics (equilibrium and irreversible), transport processes and two-phase flows.

These graduate programs lead to the degrees Master of Science in Mechanical Engineering, Master of Science and Doctor of Philosophy for qualified graduates having backgrounds in engineering, mechanics, mathematics, the physical sciences and the biological sciences.

Multidisciplinary Programs.

See table on page 71.

School Facilities

The School of Mechanical Engineering has many types of specialized instruments and equipment associated with laboratories for the study of two-phase flow, lubrication and rheology, material processing, fire hazard and combustion, magnetogas dynamics, energetics, fluidics and fluid power control, heat transfer, vibration and thermal stress, computer-aided design, automatic and digital control, machinery noise and other areas. The school is housed in a four-building classroom-research complex. Part of this complex is a modern classroom-seminar conference building which serves the institute.

The main research building of the school houses several remote terminals linked to the main campus research and teaching computer. It also has analog and micro computer facilities. The school research activity is served by its own machine and instrumentation shops with a full-time supporting staff of technicians.

Additional information about the pro-

grams may be obtained from the *Student Handbook or Graduate Student Information Brochure*, available upon request, or by calling the school at (404) 894-3203. These sources of information must be consulted with respect to special rules and degree requirements by every student enrolled.

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Chem. 1101-2 General Chemistry	4-3-5	4-3-5	.....
Phys. 2121 Particle Dynamics	.....	.....	4-3-5
Math. 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
Elective E.Gr. 1170, Introduction to Visual Communication and Engineering Design I (2-3-3) and one of the engineering electives ¹	X-X-3	X-X-3	.....
M.E. 1001 Introduction to M.E.	.....	.....	1-0-1
Electives⁴ Humanities/ Social Science/ Modern Language	3-0-3	3-0-3	3-0-3
Electives⁵ Physical Education	0-4-1	0-4-1	0-4-1
Electives² Free	2-0-2	2-0-2	2-0-2
Totals	16-10-19	16-10-19	15-7-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Phys. 2122 Electromagnetism	4-3-5	.....	.....
Phys. 2123 Optics and Modern Physics	.....	4-3-5	.....
Math. 2307 Calculus IV	5-0-5	.....	.....
Math. 2308 Calculus and Linear Algebra	.....	5-0-5	.....
Math. 2309 Differential Equations	.....	.....	5-0-5

E.S.M. 2201 Statics	3-0-3	.....	.....
E.S.M. 3201 Dynamics I	.....	.....	3-0-3
E.S.M. 3301 Mechanics of Deformable Bodies	.....	5-0-5	.....
M.E. 2212 Materials Science	.....	.....	3-0-3
Electives⁴ Humanities/Social Science/Modern Language	3-0-3	3-0-3	6-0-6
Totals	15-3-16	17-3-18	17-0-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
M.E. 3322-3-4 Thermodynamics	3-0-3	3-0-3	3-0-3
M.E. 3342-3-4 Transport Phenomena I,II, III	3-0-3	3-0-3	3-3-4
E.E. 3725 Electric Circuits and Fields	2-3-3	.....	.....
E.E. 3726 Elementary Electronics	.....	2-3-3	.....
E.E. 3727 Electric Power Conversion	.....	.....	2-3-3
M.E. 3212 Materials Technology	3-3-4	.....	.....
M.E. 3016 M.E. Computer Applications	.....	2-3-3	.....
M.E. 3055 Experimental Methodology	.....	.....	1-3-2
M.E. 3113 Mechanisms, Analysis and Synthesis	3-0-3	.....	.....
M.E. 3114 Dynamics of Machinery	.....	.....	3-0-3
M.E. 3181 Machine Elements	.....	3-0-3	.....

Electives¹

Humanities/ Social Science/ Modern Language	.....	3-0-3	3-0-3
Totals	14-6-16	16-6-18	15-9-18

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
M.E. 4183 Design Theory	3-0-3	.....	.....
M.E. 4184 Design Engineering	.....	.....	0-6-2
M.E. 4318 Thermal Systems Analysis and Design	.....	4-0-4	.....
M.E. 4055 Experimental Engineering	.....	.....	1-3-2
M.E. 4344 Transport Phenomena IV	3-0-3	.....	.....
M.E. 4212 Material Processes	.....	3-3-4	.....
M.E. 4445 Automatic Control	3-0-3	.....	.....
I.Sy.E. 4725 Engineering Economy	3-0-3	.....	.....
Electives³ Technical	.....	3-0-3	6-0-6
Electives⁴ Humanities/ Social Science/ Modern Language	3-0-3	3-0-3	3-0-3
Elective⁵ M.E. Design	.....	3-0-3	.....
Totals	15-0-15	16-3-17	10-9-13

¹ See College of Engineering section "Curricula and Degrees" for engineering electives.

² These free elective courses may be taken at any time during the course of study. If ROTC is elected by the student these six credit hours may be applied for basic ROTC, which should be scheduled beginning the first quarter the student is enrolled.

³ Nine hours of technical electives chosen from M.E. 3000, 4000 and 6000 level courses. Graduate courses (6000 level) must have consent of adviser. Courses other than these may be selected from mathematics, physics, chemistry, bi-

School of Nuclear Engineering

Established in 1962

Director—L. E. Weaver; *Callaway Professor*—W. M. Stacey, Jr.; *Neely Professor*—K.Z. Morgan; *Regents' Professor*—G. G. Eichholz; *Professors*—M. W. Carter, J. D. Clement, M. V. Davis, D. S. Harmer, B. Kahn, J. M. Kallfelz, R. A. Karam, J. L. Russell, Jr., J. H. Rust, A. Schneider; *Associate Professors*—R. G. Bateman, Jr., J. N. Davidson, J. W. Poston; *Adjunct Associate Professor*—P. H. McGinley.

General Information

Nuclear engineering is the branch of engineering directly concerned with the release, control and utilization of all types of energy from nuclear sources and its environmental impact. Today nuclear energy is being used in a wide variety of applications from the exploration of outer space and the powering of human heart pacemakers to the generation of electricity. With the limited supply of fossil fuels and the growing concern about their environmental effect, the

ology, another field of engineering or graduate courses.

A student who wishes to take courses not in M.E. must so notify the director concerning his or her choice and obtain approval at advance registration for the first quarter of his or her senior year. A lab course (2-3-3) may be scheduled in place of a (3-0-3) course. A student completing his or her junior year with a grade average of 2.5 or higher may elect one technical elective from the special problem courses M.E. 4901 through 4912. (The particular course selected depends on the number of hours of credit needed.) This student will follow a course of individual study under the guidance of a faculty member with the approval of the school director. Nine hours of electives may be replaced by advanced ROTC.

⁴ For selection of acceptable courses see list of electives allowed by the College of Engineering in "Information for Undergraduate Students."

⁵ See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

⁶ From the approved list.

need for nuclear power to produce the large amounts of energy demanded by our society becomes more and more pressing. The School of Nuclear Engineering is playing a vital role in educating the technical manpower required to meet this need.

In addition to the Bachelor of Nuclear Engineering degree, the school administers the program leading to the Bachelor of Science degree in Health Physics. Health physics is an applied science concerned with the protection of man and the environment from the hazards of radiation and chemical pollutants. Typical activities of health physicists today are: development of sound philosophy and principles of radiation protection; practical application of these principles on the job in an industrial or medical setting or with a regulatory agency; and devising new methods and instrumentation for the protection of individual workers and the general public.

Undergraduate Programs

The curriculum leading to the degree Bachelor of Nuclear Engineering is structured to meet the needs of both the student who contemplates employment immediately after graduation and the student planning to pursue graduate study. It has been tailored to provide maximum flexibility in the form of options for each student to develop his or her unique interests or capabilities. These options are built upon the core curriculum covering the basic principles of nuclear engineering: nuclear reactor core design, nuclear fuel design, reactor controls engineering, nuclear fuel process engineering, nuclear power economics and reactor operations.

Studies for the Bachelor's Degree in Health Physics may be planned to be terminal, leading to careers in radiation protection or environmental surveillance, or may be preparatory to further study at the graduate level for a professional career as a health physicist. The program also provides an excellent premedical education.

In addition to the Institute's academic requirements for graduation with a bachelor's degree, the number of quality points earned in nuclear engineering courses

taken toward the B.N.E. degree or B.S.H.P. degree must be at least twice the number of credit hours in those courses. Further, students in the B.N.E. degree program must obtain twice the number of quality points as credit hours for courses taken in thermodynamics and transport phenomena.

Program for the Bachelor of Nuclear Engineering

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Chem. 1101-2 General Chemistry	4-3-5	4-3-5	.....
Phys. 2121 Particle Dynamics	.....	.....	4-3-5
Math. 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
E.Gr. 1170 Visual Communication and Engineering Design	.....	2-3-3	.....
E.E. 1010⁶ Computer Programming and Graphics	.....	.....	2-3-3
Elective¹ Engineering	2-3-3	.....	.....
Electives² Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Elective⁵ Physical Education	0-4-1	0-4-1	0-4-1
Totals	14-10-17	14-10-17	14-10-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Phys. 2122 Electromagnetism	4-3-5	.....	.....
Phys. 2123 Optics and Modern Physics	.....	4-3-5	.....
Math. 2307 Calculus IV	5-0-5	.....	.....
Math. 2308 Calculus and Linear Algebra	.....	5-0-5	.....

Math. 2309 Ordinary Differential Equations	.....	.....	5-0-5
E.S.M. 2201 Statics	.....	3-0-3	.....
E.S.M. 3201 Dynamics	.....	.....	3-0-3
I.Sy.E. 4725³ Engineering Economy	.....	.....	3-0-3
Electives² Free	4-0-4	1-0-1	3-0-3
Elective⁶ Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Totals	16-3-17	16-3-17	17-0-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
Phys. 3001 Modern and Nuclear Physics	5-0-5	.....	.....
N.E. 3211 Elements of Nuclear Engineering	3-0-3	.....	.....
N.E. 4201-2 Nuclear Reactor Physics I and II	.....	3-0-3	3-0-3
H.P. 4412 Principles of Health Physics	.....	3-0-3	.....
N.E. 3110 Radiation Detection	.....	.....	2-6-4
E.S.M. 3301 Mechanics of Deformable Bodies	.....	.....	5-0-5
M.E. 3322-3 Thermodynamics	3-0-3	3-0-3	.....
Ch.E. 3300-1³ Transport Phenomena	.....	3-0-3	3-0-3
Ch.E. 3302³ Transport Phenomena Laboratory	.....	.....	0-3-1
Math. 4582 Advanced Engineering Mathematics	3-0-3	.....	.....

Math. 4581³ Advanced Engineering Mathematics	.....	3-0-3	.....
Electives⁶ Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Totals	17-0-17	18-0-18	16-9-19

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
N.E. 4211-2 Reactor Engineering I and II	3-0-3	3-0-3	.....
N.E. 4230 Nuclear Engineering Design	.....	.....	2-6-4
N.E. 4205 Reactor Laboratory	1-6-3	.....	.....
N.E. 4001-2-3 Nuclear Engineering Seminar	1-0-0	1-0-0	1-0-0
N.E. 4260 Radiation Transport and Shielding	.....	3-0-3	.....
Met. 4403³ Introductory Nuclear Metallurgy	.....	3-3-4	.....
Ch.E. 3303³ Transport Phenomena Laboratory	0-3-1	.....	.....
E.E. 3725 Electric Circuits and Fields	.....	.....	2-3-3
Electives⁶ Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives⁴ Technical	6-0-6	3-0-3	3-0-3
Electives² Free	.....	.....	3-0-3
Totals	14-9-16	16-3-16	14-9-16

¹ For selection of College of Engineering approved elective courses and requirements see "Curricula and Degrees." E.E. 1010 cannot be used as a substitution.

² Free elective courses may be taken at any time during the course of study. If ROTC is elected by the student, six credit hours may be applied for

basic ROTC and a maximum of five credit hours for advanced ROTC. (A maximum of nine credit hours of electives may be used for advanced ROTC—five hours free electives and four hours technical electives).

³ Other courses may be substituted for these required courses. Substitutions are available from the general office of the School of Nuclear Engineering.

⁴ The electives will be selected by the student after consultation with his or her adviser. At least 10 credit hours must be in the areas of design, synthesis and systems. A maximum of four credit hours of technical electives may be used for advanced ROTC.

⁵ See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

⁶ See "Information for Undergraduate Students."

Program for the Bachelor of Science in Health Physics

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Chem. 1101-2 General Chemistry	4-3-5	4-3-5	.....
Phys. 2121 Particle Dynamics	.....	.....	4-3-5
Math. 1307-8-9 Calculus, I, II, III	5-0-5	5-0-5	5-0-5
E.Gr. 1170 Visual Communication and Engineering Design	.....	2-3-3	.....
Elective¹ Technical	2-3-3	.....	.....
Electives² Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Elective³ Physical Education	0-4-1	0-4-1	0-4-1
Elective⁴ Free	.....	.....	3-0-3
Totals	14-10-17	14-10-17	15-7-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Phys. 2122 Electromagnetism	4-3-5	.....	.....

Phys. 2123

Optics and Modern Physics	.....	4-3-5	.....
Math. 2307 Calculus IV	5-0-5	.....	.....
Math. 2308 Calculus and Linear Algebra	.....	5-0-5	.....
Math. 2309 Ordinary Differential Equations	.....	.....	5-0-5
Biol. 2210-1 Principles of Biology	4-3-5	4-3-5	.....
E.E. 1010 Computer Programming and Graphics	.....	.....	2-3-3
H.P. 2401-2-3 Introduction to Health Physics	1-0-1	1-0-1	1-0-1
Electives⁴ Free	.....	.....	6-0-6
Electives² Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Totals	17-6-19	17-6-19	17-3-18

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
Phys. 3001 Introduction to Modern Physics	5-0-5	.....	.....
Phys. 3211 Electronics	.....	5-6-7	.....
N.E. 3110 Nuclear Radiation Detection	.....	.....	2-6-4
H.P. 4411-2-3 Radiation and Health Physics	3-3-4	3-0-3	3-3-4
Math. 4582 Advanced Engineering Mathematics	3-0-3	.....	.....
Biol. 3335 General Ecology	3-0-3	.....	.....
Biol. 4415/6730 Introduction to Radiation Biology	.....	.....	3-3-4
Biol. 3333⁵ Biostatistics	.....	3-3-4	.....

Electives²

Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Elective³			
Technical	.....	.....	3-0-3
Totals	17-3-18	14-9-17	14-12-18

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
N.E. 4001-2-3			
Nuclear Engineering Seminar	1-0-0	1-0-0	1-0-0
Chem. 4701			
Chemistry of Nuclear Technology	.....	3-3-4	.....
Phys. 4211			
Electronic Instruments	.....	2-3-3	.....
N.E. 4260			
Radiation Shielding	.....	3-0-3	.....
H.P. 4401-2-3			
Health Physics Seminar	1-0-1	1-0-1	1-0-1
H.P. 4440			
Non-ionizing Radiation	3-0-3	.....	.....
N.E. 4620			
Nuclear Technology and the Environment	.....	.....	3-0-3
N.E. 4701-2-3			
Nuclear Reactor Engineering	3-0-3	3-0-3	3-0-3
N.E. 4903			
Special Problem in Health Physics	.....	.....	0-9-3
Electives²			
Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Elective⁴			
Free	6-0-6	.....	3-0-3
Totals	17-0-16	16-6-17	14-9-16

¹ For selection of approved elective courses, see Freshman Engineering Electives in "Curricula and Degrees, College of Engineering." E.E. 1010 cannot be used as a substitution.

² See Humanities and Social Sciences Requirements in "Information for Undergraduate Students."

Graduate Program

The School of Nuclear Engineering administers programs leading to the degrees Master of Science in Nuclear Engineering, Master of Science, Master of Science in Health Physics and Doctor of Philosophy.

The program at the master's level provides 11 areas of emphasis: reactor engineering, reactor operations, nuclear fuels engineering, energy systems engineering, nuclear fuel cycle, computer applications, nuclear power management, plasma physics and fusion technology, radiation technology, environmental engineering and health physics.

These curricula are constructed from various combinations of nuclear engineering courses, supplemented with courses in other schools as appropriate. For the first eight areas, students with a Bachelor of Science degree in engineering take the Master of Science in Nuclear Engineering degree while students with a Bachelor of Science degree in science will enroll for the Master of Science Degree. Students completing studies in radiation technology or environmental engineering receive the Master of Science degree and students studying health physics receive the Master of Science in Health Physics degree.

Depending on the career objectives of the student, a thesis may be encouraged as part of the Master of Science program. When appropriate, approved courses and research experience on a special problem may be substituted for a thesis.

The doctoral program is designed with great latitude to capitalize on variations in experience and interests of individual students. In addition to the courses offered by

³ See Department of Physical Education and Recreation in "Curricula and Degrees."

⁴ If ROTC is elected by the student, a maximum of six credit hours of basic ROTC and nine credit hours of advanced ROTC may be counted as free elective hours.

⁵ Other courses in statistics or data analysis may be substituted. A list of these courses is available in the general office of the School of Nuclear Engineering.

⁶ Technical electives will be selected by the student after consultation with his or her adviser.

the School of Nuclear Engineering, students are encouraged to enroll in courses related to their subject areas that are offered by other schools.

Multidisciplinary Programs.

See table on page 71.

Facilities

The facilities available on the Georgia Tech campus for instruction and research in nuclear engineering include the following: a five megawatt research reactor, a low-power training reactor, a sub-critical assembly, a 100,000 curie cobalt-60 source, several small digital computers, a CDC CYBER 70-74-28 computer, hot cells for handling radioactive materials, a complete nuclear instrumentation laboratory, and facilities for analyzing environmental samples by nuclear techniques.

School of Textile Engineering

Established in 1899

Acting Director—Wayne C. Tincher; *Callaway Professor*—John L. Lundberg; *Professors*—Winston C. Boteler, Walter C. Carter, W. Denney Freeston; *Associate Professors*—Milos Konopasek, L. Howard Olson; *Assistant Professors*—Agaram S. Abhiraman, David Brookstein, Fred L. Cook.

General Information

Textiles, one of man's oldest commercial ventures, continues to find new applications in the modern world. Fiber assemblies have many varied uses in our everyday life and are playing critical roles in new complex systems in space, medicine, safety, environmental control, transportation and construction.

Textile engineering encompasses the synthesis of polymers by nature and man, fiber fabrication processes, assembling of fibers into one-, two- and three-dimensional structures, modification of structural

properties through dyeing, finishing and coating, and measurement of complex aesthetic and mechanical properties of fiber-based systems. New polymers and fibers, new methods of assembling fibers into useful products and new applications of fibers are being developed continually.

The School of Textile Engineering prepares students for rewarding careers in the polymer-fiber-textile industry. Graduates have positions in manufacturing supervision, technical service, sales, product and process development, research, quality control and corporate management. They participate in the design, development, manufacturing and marketing of a broad range of fiber-based and associated products. Many hold key management decision-making positions at a young age.

The textile industry is by far the largest manufacturing industry and employer in the Southeast. If apparel and other associated segments of the industry are included, the textile-based industry is the largest in the United States, representing one out of every eight manufacturing jobs. This is more than five times the number employed in the automobile industry. The textile industry's needs for textile graduates each year far exceeds the number of graduates.

Multidisciplinary Programs.

See table on page 71.

Curricula

Three study programs are available leading to the degrees Bachelor of Textile Engineering, Bachelor of Science in Textile Chemistry and Bachelor of Science in Textiles. Each degree may be pursued in a regular four-year program or the five-year cooperative plan.

A broad background is stressed because of the multidisciplinary nature of textiles. Emphasis in the freshman and sophomore years is on mathematics, chemistry and physics, and in the junior and senior years on materials science, polymer and textile chemistry, applied mechanics, business administration and application of each field to the broad range of problems encountered in textiles. All three programs provide for student selection of a number of

courses from a wide range of general and technical electives.

In place of the many conventional laboratory sessions, textile students participate in a student operated and managed business venture. Students design, develop, produce and market novelty textile products. Every participant is exposed to all facets of the business environment.

Since most of the textile course work is concentrated in the last two years of the programs, students from junior colleges and community colleges can readily transfer into selected programs of the School of Textile Engineering.

In addition to campus-wide academic requirements for graduation with a bachelor's degree, the number of quality points earned in textile courses taken toward the degree must be at least twice the number of credit hours in those courses.

Textiles For Other Majors

Students with other majors often enter the textile industry. To further their careers, the School of Textile Engineering has developed coordinated course offerings that will be helpful to students with this goal. Listings of recommended course sequences in textiles are available in the School of Textile Engineering office.

Graduate Program

The School of Textile Engineering has a graduate program leading to the Master of Science and Doctor of Philosophy degrees. Students holding an undergraduate degree in any one of several fields of science or engineering may qualify for admission. An undergraduate degree in textile engineering, textiles or textile chemistry is not a specific requirement. Each student pursues an individually structured program.

The graduate course offerings encompass advanced study and research in polymer synthesis, mechanics of fibrous structures, process dynamics, dyeing and dye synthesis, viscoelasticity, experimental design, properties of materials, polymer flow, polymer environmental stability, process control, energetics and kinetics. The School of Textile Engineering has a variety

of active research programs in which students participate.

The School of Textile Engineering is housed in the Hightower Building, a four-story classroom and laboratory facility. The building contains equipment illustrating most major types of textile processing. Well equipped laboratories are also available for the chemical and physical characterization of polymers, fibers and fiber assemblies. Specialized equipment is available for fabric flammability studies, polymer environmental stability experiments, fiber-reinforced composite testing, and energy conservation and water pollution studies. Machine shop and instrumentation facilities with full-time supporting technicians are housed within the building.

Program for Bachelor of Textile Engineering Degree

Freshman Year

<i>Course</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Chem. 1101-2 General Chemistry	4-3-5	4-3-5	.....
E.Gr. 1170 Visual Communication and Engineering Design I	2-3-3	.....	.....
Math. 1307-8-9 Calculus, I, II, III	5-0-5	5-0-5	5-0-5
Phys. 2121 Particle Dynamics	.....	.....	4-3-5
Electives¹ Physical Education	0-4-1	0-4-1	0-4-1
Text. 1100 Introduction to Textile Engineering	.....	3-0-3	.....
Elective Humanities/Social Science/Modern Language	.....	.....	3-0-3
I.C.S. 2250 Technical Information Resources	.....	.....	1-0-1
Electives²	2-0-2	2-0-2	2-0-2
Totals	13-10-16	14-7-16	15-7-17

Sophomore Year

<i>Course</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
E.S.M. 2201 Statics	3-0-3	.....	.....
E.S.M. 3201 Dynamics I	.....	3-0-3	.....
Math. 2307-8 Calculus IV, V	5-0-5	5-0-5	.....
Phys. 2122-3 Electromagnetism, Optics and Modern Physics	4-3-5	4-3-5	.....
Text. 3400 Computer Applications in Textiles	.....	.....	2-3-3
Text. 4200 Fiber Science	.....	.....	3-0-3
Text. 4201 Mechanics of Fibrous Structures I	.....	.....	3-0-3
Text. 2180 Textile Manufacturing Processes I	0-3-1	.....	.....
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives²	.....	.....	6-0-6
Totals	15-6-17	15-3-16	17-3-18

Junior Year

<i>Course</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
E.S.M. 3301 Mechanics of Deformable Bodies	5-0-5	.....	.....
E.S.M. 3302 Mechanics of Materials	3-0-3	.....
M.E. 3720 Thermodynamics	4-0-4
I.Sy.E. 3749 Elementary Quality Control	3-0-3
Text. 4751 Polymer Science and Engineering II	3-0-3	.....
Text. 4305 Chemical Preparation and Finishing of Textiles	3-0-3

Text. 4202-3

Mechanics of Fibrous Structures II, III	3-0-3	.....	3-0-3
Text. 2181-2 Textile Manufacturing Processes II, III	0-3-1	0-3-1	.....
Engl. 3023 Written Communication	3-0-3	.....	.....
Electives Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives²	3-0-3	6-0-6	.....
Totals	17-3-18	15-3-16	16-0-16

Senior Year

<i>Course</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
C.E. 3053-4 Fluid Mechanics I, II	.....	3-0-3	3-3-4
E.E. 3725 Electrical Circuits and Fields	2-3-3	.....	.....
E.E. 3726 Elementary Electronics	.....	2-3-3	.....
E.E. 3727 Electric Power Conversion	.....	.....	2-3-3
Text. 4306 Dyeing and Printing	3-3-4	.....	.....
Text. 3750 Elementary Heat and Mass Transfer	.....	3-0-3	.....
Text. 4420 Analysis of Textile Materials	3-3-4	.....	.....
I.Sy.E. 4725 Engineering Economy	.....	3-0-3	.....
Text. 4402-3-4 Seminar	1-0-0	1-0-0	1-0-1
Text. 3480-1 Textile Manufacturing Processes IV, V	0-3-1	0-3-1	.....
Text. 3484 Problems in Textile Management II	.....	.....	0-3-1
Text. 4901³ Special Problems	.....	0-3-1	0-3-1

Electives

Humanities/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives²	.....	.....	3-0-3
Totals	12-12-15	15-9-17	12-12-16

¹ See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

² Twelve hours of electives must be approved by the department. Six must be humanities/social science/modern language. These free electives may be taken at any time during a student's course of study. Up to six hours of basic ROTC and a maximum of nine hours of advanced ROTC may be used for elective credit.

³ Text. 4481-2 can be substituted for Text. 4900-1.

Program for the Bachelor of Science in Textiles Degree

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Chem. 1101-2 General Chemistry	4-3-5	4-3-5	.....
Engl. 1001-2-3 Analysis of Literature	3-0-3	3-0-3	3-0-3
Math. 1711-2-3 Mathematics for Management I, II, III	5-0-5	5-0-5	5-0-5
Text. 1100 Introduction to Textile Engineering	.....	3-0-3	.....
Text. 2100 Introduction to Fiber Science	.....	.....	3-0-3
Electives¹ Physical Education	0-4-1	0-4-1	0-4-1
Electives²	2-0-2	2-0-2	2-0-2
Totals	14-7-16	17-7-19	13-4-14

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Phys. 2111-2-3 Physics	4-0-4	4-0-4	4-0-4
Engl. 3023 Written Communication	.....	.....	3-0-3

Econ. 2000-1

Economic Principles and Problems	3-0-3	3-0-3
E.Gr. 1170 Introduction to Visual Communications and Engineering Design I	2-3-3

Text. 2101

Yarn Processing I	3-0-3
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Text. 3110

Woven Structures I	3-0-3
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Text. 3112

Knit Fabrics	3-0-3
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Text. 2180-1-2

Textile Manufacturing Processes I, II, III	0-3-1	0-3-1	0-3-1
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Electives²

	6-0-6	6-0-6	3-0-3
Totals	15-6-17	16-3-17	16-3-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
Text. 3122 Structures of Organic Polymers	3-0-3	.....	.....
Text. 4305 Chemical Preparation and Finishing of Textiles	.....	3-0-3	.....
Text. 3113 Nonwoven Fabrics	3-0-3	.....	.....
Text. 3400 Computer Applications in Textiles	.....	.....	2-3-3
Mgt. 2000-1 Accounting I, II	3-0-3	3-0-3	.....
Mgt. 3060 Financial Management	.....	.....	3-0-3
Mgt. 3300 Marketing I	3-0-3	.....	.....
Text. 4200 Fiber Science	.....	3-0-3	.....
I.Sy.E. 3749 Elementary Quality Control	.....	.....	3-0-3
Text. 3480-1-2 Textile Manufacturing Processes IV, V, VI	0-3-1	0-3-1	0-3-1

Text. 3483-4

Problems in Textile Management I, II	0-3-1	0-3-1	.....
Electives²	3-0-3	6-0-6	6-0-6
Totals	15-6-17	15-6-17	14-6-16

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
Text. 4420 Analysis of Textile Materials	3-3-4	.....	.....
Text. 4402-3-4 Seminar	1-0-0	1-0-0	1-0-1
I.C.S. 2250 Technical Information Resources	1-0-1	.....	.....
Text. 4100 Textile Management Decision-Making	.....	2-3-3	.....
Text. 4306 Dyeing and Printing	3-3-4	.....	.....
Text. 4101 Planning and Control in Textile Production Systems	.....	.....	3-0-3
Psy. 4401 Industrial Psychology	.....	.....	3-0-3
Mgt. 4200 Industrial Relations	.....	.....	3-0-3
I.Sy.E. 3115 I.Sy.E. Measurements	3-0-3	.....	.....
Mgt. 3150 Industrial Management Principles	.....	3-0-3	.....
Text. 3485 Problems in Textile Management III	0-3-1	.....	.....
Text. 4480 Problems in Production Supervision	0-3-1	.....	.....
Elective Either Text. 4481-2, Advanced Problems in Textile Management and Production Innovation or Text. 4900-1, Special Problems	.....	0-3-1	0-3-1
Electives²	3-0-3	6-0-6	6-0-6
Totals	14-12-17	12-6-13	16-3-17

¹ See "Curricula and Degrees," Department of Physical Education and Recreation for freshman physical education requirements for both men and women.

² Twelve hours of electives must be approved by the department. Twenty-one must be humanities/social science/modern language electives. These free electives may be taken at any time during a student's course of study. Up to six hours of basic ROTC and a maximum of nine hours of advanced ROTC may be used for elective credit.

Program for Bachelor of Science in Textile Chemistry

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Chem. 1101-2¹ General Chemistry	4-3-5	4-3-5	.....
Chem. 2113 Chemical Principles	.....	.....	3-3-4
Text. 1100 Introduction to Textile Engineering	.....	3-0-3	.....
Engl. 1001-2-3 Analysis of Literature	3-0-3	3-0-3	3-0-3
Math. 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
I.C.S. 2250 Technical Information Resources	.....	.....	1-0-1
Electives² Physical Education	0-4-1	0-4-1	0-4-1
Electives³	2-0-2	2-0-2	2-0-2
Totals	14-7-16	17-7-19	14-7-16

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Chem. 3311-2-3 Organic Chemistry	3-0-3	3-0-3	3-0-3
Chem. 3381-2 Organic Chemistry Laboratory	.....	0-6-2	0-6-2
Math. 2307-8 Calculus IV, V	5-0-5	5-0-5	.....
Phys. 2121 Particle Dynamics	4-3-5	.....	.....
Phys. 2122 Electromagnetism	.....	4-3-5	.....

Phys. 2123 Optics and Modern Physics	.....	.....	4-3-5
Engl. 3023 Written Communication	.....	.....	3-0-3
E.Gr. 1170 Visual Communication and Engineering Design I	2-3-3	.....	.....
Text. 3400 Computer Applications in Textiles	.....	.....	2-3-3
Electives³	3-0-3	3-0-3	.....
Totals	17-6-19	15-9-18	12-12-16

Junior Year			
Course	1st Q.	2nd Q.	3rd Q.
Chem. 3412-3 Physical Chemistry	3-0-3	3-0-3	.....
Chem. 3481 Physical Chemistry Laboratory	.....	0-6-2	.....
I.Sy.E. 3749 Elementary Quality Control	.....	3-0-3	.....
Text. 4310⁴ Textile Instrumental Analysis	.....	.....	2-3-3
Text. 4750-1 Polymer Science and Engineering I, II	.....	3-0-3	3-0-3
Text. 4200 Fiber Science	3-0-3	.....	.....
Text. 4300 Chemistry and Chemical Processing of Fibers and Textiles I	.....	.....	3-0-3
Text. 2180 Textile Manufacturing Processes I	0-3-1	.....	.....
Electives³	9-0-9	6-0-6	6-0-6
Totals	15-3-16	15-6-17	14-3-15

Senior Year			
Course	1st Q.	2nd Q.	3rd Q.
Text. 4420 Analysis of Textile Materials	3-3-4	.....	.....
Text. 4402-3-4 Seminar	1-0-0	1-0-0	1-0-1
Text. 4301 Chemistry and Chemical Processing of Fibers and Textiles II	3-3-4	.....	.....
Text. 4302 Textile Finishing Processes	.....	3-0-3	.....
Text. 4503 Science of Color	.....	3-0-3	.....
Text. 4201-2 Mechanics of Fibrous Structures I, II	3-0-3	.....	3-0-3
Text. 3480-1-2 Textile Manufacturing Processes IV, V, VI	0-3-1	0-3-1	0-3-1
Text. 4900-1⁵ Special Problems	.....	0-3-1	0-3-1
Electives³	3-0-3	6-0-6	12-0-12
Totals	13-9-15	13-6-14	16-6-18

¹ Chem. 1111-2 can be substituted for Chem. 1101-2.

² See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

³ Fifteen hours of electives must be approved by the department. Twenty-seven hours must be humanities/social science/modern language electives. These free electives may be taken at any time during a student's course of study. Up to six hours of basic ROTC and a maximum of nine hours of advanced ROTC may be used for elective credit.

⁴ Chem. 4201 can be substituted for Text. 4310.

⁵ Text. 4480-1 can be substituted for Text. 4900-1.

COLLEGE OF MANAGEMENT

Established in 1969, school in 1948, department in 1934, School of Commerce in 1913

Dean—Charles E. Gearing; *Associate Dean*—Milton R. Blood; *Assistant Deans*—Andrew J. Cooper, III, Marilu McCarty; *Regents' Professor*—Glenn W. Gilman; *Mills B. Lane Professor*—Bernell K. Stone; *Professors*—Aristides F. Abril, Philip Adler, Fred C. Allvine, W. Carl Biven, E. R. Bollinger, Robert W. Carney, Kong Chu, Sherman F. Dallas, Ramon G. Gamoneda, R. Earl Green, Robert G. Jeroslow, Ferdinand K. Levy, Mack A. Moore, Roderick F. O'Connor, Leonard J. Parsons, William A. Schaffer, Matthew J. Sobel, Fred A. Tarpley, Jr., Gerrit Wolf; *Associate Professors*—Peter H. Aranson, L. Harlan Davis, Gerald J. Day, David M. Herold, John R. Kaatz, Jack Kleiner, James A. Largay, III, Michael S. Long, George E. Mad-dox, David C. Nachman, Peter G. Sassone, Myron B. Slovin, Richard D. Teach, Fred E. Williams; *Assistant Professors*—Susan I. Cohen, Edward J. Conlon, Modesto Garcia, Marlin V. Law, Naresh K. Malhotra, Tom W. Miller, George E. Monahan, Charles K. Parsons; *Lecturers*—William L. Ashley, William L. Griffith.

General Information

The College of Management prepares students for careers as managers or for additional study at the graduate level, stressing long-range career objectives rather than specific job knowledge. The continuing growth in number of organizations and the increasing complexity of modern industrial and governmental operations have resulted in a great need for college graduates with formal preparation in management and economics.

The College of Management offers three undergraduate programs leading to the Bachelor of Science in Industrial Management, the Bachelor of Science in Management Science and the Bachelor of Science in Economics; and offers graduate pro-

grams leading to the Master of Science in Industrial Management, the undesignated Master of Science and the Doctor of Philosophy.

All three undergraduate degree programs contain an essentially common core. Each program allows sufficient flexibility for the student to follow his or her own educational goals. Complex problem-solving takes place in a technical, social and political environment; therefore, the tools of management and economics are enhanced by an understanding of the natural and life sciences, humanities, the social sciences and the environment of the business enterprise. Every student is thus required to take substantial work in these subjects in addition to courses such as accounting, economics, computer applications, marketing, production and finance.

Only students who demonstrate their ability to successfully complete the requirements of the program are permitted to transfer into the College of Management from other majors at Tech. Therefore, it is definitely to the student's advantage to determine as early as possible in consultation with the associate dean of the College of Management the requirements that must be met before transfer will be permitted.

Bachelor of Science in Industrial Management

The industrial management degree program develops students with a broad interest in all management activities and operating problems. The program builds upon knowledge of the functional, environmental, behavioral, economic and legal aspects of business, and provides analytic and conceptual tools for analyzing complicated problems. It prepares the student for managerial responsibilities and decision-making. The large number of elective hours allows the student, with his or her adviser, to tailor a program to his or her individual educational objectives. Elective concentration may be developed in such areas as organizational behavior, finance, accounting, computer applications, marketing, industrial relations and general management.

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Electives¹ Science	X-X-4	X-X-4	X-X-4
Engl. 1001-2-3 Introduction to Literature	3-0-3	3-0-3	3-0-3
Elective Social Science or Modern Language	.....	.....	3-0-3
Electives² Mathematics	5-0-5	5-0-5	5-0-5
Elective³ Physical Education	0-4-1	0-4-1	0-4-1
Elective⁴ History	3-0-3	.....	.....
Elective⁵ American Government	.....	3-0-3	.....
Totals	16	16	16

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Electives⁶ Engineering/Science/Mathematics/Architecture	X-X-3	X-X-3	X-X-3
Engl.⁷ 2001-2-3 Survey of the Humanities	3-0-3	3-0-3	3-0-3
Econ. 2000-1 Principles of Economics I, II	.....	3-0-3	3-0-3
Mgt. 2000-1-2 Accounting I, II, III	3-0-3	3-0-3	3-0-3
M.Sci. 2000 Management Applications of Data Processing	2-3-3	.....	.....
Electives Non-Industrial Management	3-0-3	3-0-3	3-0-3
Totals	15	15	15

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
Electives⁸ Intermediate Economics	3-0-3	3-0-3	.....

Elective

M.Sci. 3100, Survey of Statistics	3-0-3	.....	.....
M.Sci. 3400 Analytical Methods in Management I	.....	3-0-3	.....
Mgt. 3260 or 3261 Law I, Law II	.....	.....	3-0-3
Mgt. 3060 Finance I	.....	3-0-3	.....
Mgt. 3300 Marketing I	3-0-3	.....	.....
Elective⁹ Marketing	.....	3-0-3	.....
Engl. 3015 Public Speaking	.....	.....	3-0-3
Mgt. 3150 Management Theory	3-0-3	.....	.....
Electives Department Approved	.....	3-0-3	3-0-3
Mgt. 4350 Production Management	.....	.....	3-0-3
Elective Either Mgt. 3061, Finance II or Mgt. 3070, Management Science Models in Finance	.....	.....	3-0-3
Mgt. 4200 Industrial Relations	3-0-3	.....	.....
Totals	15-0-15	15-0-15	15-0-15

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
Elective¹⁰ Organizational Behavior	3-0-3	.....	.....
Electives Department Approved	6-0-6	6-0-6	3-0-3
Electives Free	3-0-3	6-0-6	9-0-9
Elective Psychology/Social Science/Modern Language	3-0-3	3-0-3	.....

Mgt. 4195

Integrated Management Problems	.....	.....	3-0-3
Totals	15-0-15	15-0-15	15-0-15

¹ Science—one year of science is required in chemistry, biology or physics (complete series).

² Unless notified to the contrary, all I.M. students are expected to satisfy the mathematics requirement with the sequence Math. 1711-12-13. Students may use the sequence 1307-8-9, 2307-8 with approval of the dean of the Mgt. college. Some students, based on their high school background, will be notified by the Mgt. office that they may satisfy the mathematics requirement with Math. 1710-11-12. Transfer students into the college must consult with the Mgt. office to determine their mathematics requirement at the time of transfer.

³ No student may receive credit for more than three hours of P.E. towards degree. See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

⁴ U.S.-Georgia History to be satisfied with one of the following: Hist. 1001, 1002, 3010, 3011.

⁵ U.S.-Georgia Constitution to be satisfied with Pol. 1251 or Pol. 3200.

⁶ One year required of approved engineering courses, architecture, science or advanced math not required by the core curriculum. Students should consult the IM Handbook for restrictions.

⁷ English 2004 or 2007 may be substituted for English 2003.

⁸ Choice of two of the intermediate economics courses 3000, 3001, 3002.

⁹ Mgt. 3301, 3310, 3320, 3330, 4331 or 4335.

¹⁰ Mgt. 3100, 4100 or 4110.

Bachelor of Science in Economics

Among the complex problems facing society today, economic issues stand in the forefront. Social objectives such as full employment, price stability, economic growth, adaptation to technological advances, efficiency in the management of complex industrial organizations and international prosperity all receive high priority on the nation's agenda. The program in economics, based on the management core, enables students to analyze complex economic problems and to understand policies for their solution.

Modern economics is analytically rigorous. The curriculum for this option prepares the student to cope with the advances that have been made in this field of study. The program requires a background in mathematics, statistics and economic theory.

A degree in economics is suitable for students who wish to major in an academic discipline, as opposed to a professional discipline, at the undergraduate level. Students also obtain professional management training through the elective courses in management. The degree in economics provides an excellent background for graduate work in economics, other social sciences or management.

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Electives¹ Science	X-X-4	X-X-4	X-X-4
Engl. 1001-2-3 Introduction to Literature	3-0-3	3-0-3	3-0-3
Electives Psychology/Social Science/Modern Language	3-0-3	3-0-3	3-0-3
Electives² Mathematics	5-0-5	5-0-5	5-0-5
Electives³ Physical Education	0-4-1	0-4-1	0-4-1
Totals	16	16	16

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Electives⁴ Engineering/Science/Mathematics/Architecture	X-X-3	X-X-3	X-X-3
Engl.⁵ 2001-2-3 Survey of the Humanities	3-0-3	3-0-3	3-0-3
Mgt. 2000-1 Accounting I, II	3-0-3	3-0-3	.....
Econ. 2000-1 Principles of Economics I, II	3-0-3	3-0-3	.....

Econ. 3000 Economic Theory of the Firm	.....	.....	3-0-3
M.Sci. 2000 Management Applications of Data Processing	3-0-3	.....	.....
Elective Modern Language/Social Science/Psychology	.....	3-0-3	.....
Elective Free	.....	.....	6-0-6
Totals	15	15	15

Junior Year <i>Course</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Econ. 3001 National Income Analysis	3-0-3	.....	.....
Econ. 3002 Money and Banking	.....	3-0-3	.....
M.Sci. 3110-1 Statistics I, II	3-0-3	3-0-3	.....
M.Sci. 3400 Analytical Methods in Management I	.....	3-0-3	.....
Mgt. 3150 Management Theory	3-0-3	.....	.....
Mgt. 3060-1 Finance I, II	3-0-3	3-0-3	.....
Mgt. 3300⁵ Marketing I	3-0-3	.....	.....
Elective⁶ Marketing	.....	3-0-3	.....
Mgt. 4350 Production Management	.....	.....	3-0-3
Engl. 3015 Public Speaking	.....	.....	3-0-3
Econ. 3100 Econometrics I	.....	.....	3-0-3
Econ. 4000 Topics in Advanced Microeconomics	.....	.....	3-0-3
Mgt. 4200 Industrial Relations	.....	.....	3-0-3
Totals	15-0-15	15-0-15	15-0-15

Senior Year <i>Course</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Elective⁷ Organizational Behavior	3-0-3	.....	.....
Elective Modern Language/Social Science/Psychology	3-0-3	.....	.....
Elective Economics	9-0-9	3-0-3	3-0-3
Electives Free	.....	6-0-6	9-0-9
Econ. 4050 Monetary Theory and Policy	.....	3-0-3	.....
Econ. 4400 History of Economic Thought	.....	3-0-3	.....
Econ. 3095 Economic Policy	.....	.....	3-0-3
Totals	15-0-15	15-0-15	15-0-15

¹ One year of science is required in chemistry, biology or physics. Must complete series in same area.

² This mathematics requirement may be satisfied by one of the following sequences as determined by the student's background from high school: Math. 1711, 1712, 1713; Math. 1307, 1308, 1711, 1713 or Math. 1307, 1308, 1309, 2307, 2308.

³ No student may receive credit for more than three hours of P.E. towards degree. See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

⁴ One year required of approved engineering courses, science, architecture or advanced math not required by the core curriculum. Students should consult the Economics Handbook for restrictions.

⁵ Engl. 2004 or 2007 may be substituted for Engl. 2003.

⁶ May substitute any course taught by the Mgt. college.

⁷ Mgt. 3100, 4100 or 4110.

Bachelor of Science in Management Science

The management science program is designed for the student who possesses strength and interest in applying mathe-

matics to managerial problems. The program, based upon a foundation of applied mathematics and the institutional aspects of the modern business, develops analytic modes organized to allocate resources within the firm. The curriculum also contains a three-course sequence of specialization which permits the student either to concentrate in an applied area or to strengthen his or her theoretical foundation.

Graduates of the option will typically be employed as staff analysts in industry and government, as systems analysts or in a wide variety of positions where a high degree of analytic ability is required. The program also provides a strong base for graduate study in business, economics, management science, operations research and related areas.

Freshman Year <i>Course</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Elective¹ Science	X-X-4	X-X-4	X-X-4
Engl. 1001-2-3 Introduction to Literature	3-0-3	3-0-3	3-0-3
Math. 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
Electives Modern Language/Social Science/Psychology	3-0-3	3-0-3	3-0-3
Elective² Physical Education	0-4-1	0-4-1	0-4-1
Totals	16	16	16

Sophomore Year <i>Course</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
Engl.³ 2001-2-3 Survey of the Humanities	3-0-3	3-0-3	3-0-3
Math. 2307-8 Calculus IV, V	5-0-5	5-0-5	.....
Econ. 2000-1 Principles of Economics I, II	3-0-3	3-0-3	.....
Econ. 3000 Economic Theory of the Firm	.....	.....	3-0-3

M.Sci. 2000 Management Application of Data Processing	3-0-3	.....	.....
Mgt. 2000-1 Accounting I, II	3-0-3	3-0-3	.....
Mgt. 3150 Management Theory	.....	.....	3-0-3
Elective Department Approved	.....	1-0-1	6-0-6
Totals	17-0-17	15-0-15	15-0-15

Junior Year <i>Course</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
M.Sci. 3200-1 Management Science I, II	3-0-3	3-0-3	.....
Math. 3215 Problems in Probability and Statistics	5-0-5	.....	.....
Math. 3716 Statistics for Management Science	.....	5-0-5	.....
Mgt. 4200 Industrial Relations	3-0-3	.....	.....
Elective⁷ Organization Behavior	3-0-3	.....	.....
Mgt. 3060 Finance I	.....	3-0-3	.....
Mgt. 3300 Marketing I	.....	3-0-3	.....
Econ. 3100 Econometrics	.....	.....	3-0-3
Elective Marketing	.....	.....	3-0-3
Mgt. 3070 Management Science Models in Finance	.....	.....	3-0-3
Engl. 3015 Public Speaking	.....	.....	3-0-3
Mgt. 4350 Production Management	.....	.....	3-0-3
Totals	14-0-14	14-0-14	15-0-15

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
Electives⁴			
Management Science Concentration			9
Electives⁵			
Advanced Mathematics		6	
Electives⁶			
Specialization or Project			9
Electives			
Free		18	
Mgt. 4195			
Integrated Management Problems			3
Total Senior Year			45

¹ One year of science is required in chemistry, biology or physics (complete series).

² No student may receive credit for more than three hours of P.E. toward degree. See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

³ Engl. 2004 or 2007 may be substituted for Engl. 2003.

⁴ M.Sci. concentration electives, subject to M.Sci. adviser's approval are nine hours selected from Math. 3643, 4580, 4582, 4583, 4221, 4222, 4280, 4281, 4282, 4283, 4591, 4643, 4644, 4645, I.Sy.E. 4005, 4006, 4007, 4010, 4011, 4028, 4044, 4053, 4056 and M.Sci. 3300, 3401, 3402, 4110, 4120, 6101, 6102, 6105, 6106, 6410.

⁵ Advanced math electives, subject to M.Sci. adviser's approval, six hours selected from Math. 2020, 3110, 4110, 4120, 4431, 4038, 4140, 4311-3, 4391, 4392, 4441, 4643, 4644, 4645.

⁶ Specialization electives, subject to M.Sci. adviser's approval, nine hours in a specific subject area to be chosen from I.C.S. 2600, 2700, 3113, 3400, 3422, 3600, 3601, 4300, 4305, 4334, 4380, 4410, 4430, 4560, Psy. 4401, 4402, 4403, 4404, 4405, 4407, 4410, 4411, 4424, 4750 or from the courses listed under M.Sci. concentration electives or nine hours of special project M.Sci. 4991, 4992 and 4993 or advanced electives in accounting, finance or marketing.

⁷ Mgt. 3100, 4100 or 4110.

Graduate Programs

The College of Management offers graduate programs leading to the degrees of Master of Science in Industrial Management (M.S.I.M.), the undesignated Master of Science and the Doctor of Philosophy.

The Master of Science in Industrial Management program provides a professional management education for students with baccalaureate degrees in any discipline. Calculus is the only prerequisite. Special coursework is provided during the summer so that students with insufficient mathematical training can acquire the necessary skills before entering the program.

The M.S.I.M. program comprises 24 courses (normally 72 hours), 15 of which are required. These 15 courses form a common core of knowledge required of all M.S.I.M. students. The remaining 9 elective courses provide considerable flexibility for students to build competence in one or more concentration areas. This freedom permits each student to fashion a unique curriculum directed to individual educational and career goals. Available concentration areas include accounting, economics, finance, general management, labor relations, management science, marketing, organizational behavior (including human resource management), and production and operations management.

Entry is in the fall quarter and the typical course load is four courses per quarter. Most of the common core is completed in the first academic year. Students with appropriate background are encouraged to substitute suitable advanced courses for some basic core requirements. Summer coursework is minimal and students are encouraged to gain relevant work experience during the summer between the first and second years of the program. Only 3 required courses are scheduled in the second year so that most of that year's effort is devoted to concentration area(s) and electives.

The M.S.I.M. program is accredited by the American Assembly of Collegiate Schools of Business.

The undesignated Master of Science degree program is designed to serve stu-

dents whose educational and career goals might not be best served by the M.S.I.M. program. Under these circumstances the student can pursue a master's level curriculum specifically designed for his or her individual needs. The course requirements for such a curriculum are determined by the student and an academic adviser. Individually designed programs must be approved in advance by the Chairman of Master's Programs and the Curriculum Committee of the College of Management.

The doctoral program in the College of Management is designed to complement and reflect the technological emphasis of the Institute. All doctoral students are required to acquire expertise in both teaching and research.

Comprehensive examinations, which include both a general and a special examination, are required of all doctoral students. The general examination will be given when the student completes one full year of graduate work, the special examination when the student completes his or her course work. The student will be admitted to candidacy after successful completion of the special examination and the approval of the prospectus of his or her dissertation. On completion of the dissertation the student will be required to take a final oral examination as prescribed in the general regulations of the graduate division.

COLLEGE OF SCIENCES AND LIBERAL STUDIES

The College of Sciences and Liberal Studies comprises eight degree-granting schools and seven nondegree-granting departments. These units offer a range of courses in the sciences, humanities, physical education and ROTC sufficient to provide the student in any degree program ample opportunity to lay the foundations of a genuine education.

The degree programs in each of the sciences are described in detail under the appropriate school heading. These programs, both undergraduate and graduate, have been designed with sufficient flexibility to provide a strong base in the chosen discipline and accommodate a variety of career objectives. For example, a number of graduate programs in the life sciences are available in biology, chemistry, physics and psychology. These programs provide the student with the opportunity to take advanced courses in interdisciplinary areas and to undertake thesis research under the joint direction of faculty members from different departments. Interdisciplinary programs in biochemistry, biophysics, molecular genetics, microbiology and psychobiology are available, and the broad research interests of the life sciences faculty provide the student with a very wide choice of thesis problems.

Department of Air Force Aerospace Studies

Established in 1950

Professor and Head—Colonel James L. Priest; *Assistant Professors*—Major Wilmoughby G. Burns, III, Captain Timothy J. Monaghan.

General Information

Air Force Reserve Officer Training Corps (AFROTC) program is divided into two phases. The first two years constitute the General Military Course (G.M.C.) and the last two years, the Professional Officer Course (P.O.C.).

Four-Year Program

Students entering the four-year program enroll in AFROTC courses in the same manner in which they register for other undergraduate courses. A formal application is not required. Students enrolled in the G.M.C. incur no military obligation. Students must compete for entry into the P.O.C., which is normally taken during the last two years of college. Selection is based upon the results of an Air Force medical examination, an Officer Qualifying Test, SAT scores and an interview by a board of Air Force officers. Cadets normally attend a four-week field training session conducted at an Air Force base between their sophomore and junior years. Co-op students may attend field training after graduation. Students accepted for the P.O.C. become members of the Air Force Reserve and receive a \$100 per month tax-free subsistence allowance.

Two-Year Program

The two-year program and the last two years of the four-year program are identical in academic content. The basic requirement for entry into this program is that the student must have two academic years remaining in school. This may be at the undergraduate or graduate level, or a combination of the two. Selection of two-year applicants is predicated upon the same criteria as four-year program cadets. In addition, candidates must successfully complete a six-week field training course at an Air Force base during the summer preceding their enrollment. Applicants enter the P.O.C. upon their return to campus.

AFROTC College Scholarship Program

AFROTC college scholarships are available to qualified cadets in the two- and four-year programs. Scholarships cover tuition, matriculation, health services, student activities fees and books. All scholarship cadets also receive a \$100 per month tax-free subsistence allowance.

School of Biology

Established in 1960

Director—John W. Crenshaw, Jr.; **Professors**—William F. Bale, Walter L. Bloom, Robert H. Fetner, Edward L. Fincher, Jerry S. Hubbard, David W. Menzel (Adjunct), **Associate Professors**—Arthur C. Benke, David B. Dusenbery, Dwight H. Hall, John J. Heise, N. W. Walls, Edward K. Yeagers; **Assistant Professors**—Gary L. Anderson, James A. Diez, E. Lloyd Dunn, David M. Gillespie, Roger B. Hanson (Adjunct), Judith G. Morgan, Roger M. Wartell; **Lecturer**—William H. Walker.

General Information

Programs of study offered by the School of Biology are designed to lead to competence in this basic science. The Institute, with its strength in science and technology, provides unique opportunities for training and research in biology. The curriculum encourages program enrichment by incorporating course selections from other schools and departments.

The Bachelor of Science degree program provides for a combination of requirements and electives that ensure the attainment of a broad background in biology with sufficient flexibility to satisfy a wide spectrum of individual interests and career objectives. The undergraduate curriculum in biology is well suited to prepare students for graduate study or for medicine, dentistry or other health profession schools.

Optional courses of study are available for the undergraduate degree providing for specialization in a biological field, or for bioengineering studies in biology and mechanics or in biology and electronics. The latter combinations lead to the undergraduate degree biomechanics option and electronics option respectively.

The School of Biology offers graduate work leading to the Master of Science degree. Programs are flexible and are designed to serve the specific needs of the student. Interdisciplinary programs involving other schools within the Institute are encouraged.

Members of the faculty are actively engaged in such research fields as aerobiology, biophysics, cell physiology, mammalian physiology, tumor immunology, ecology, microbiology, microbial and population genetics and radiation cytogenetics. Areas of strength include biophysics, ecology, genetics, microbiology and physiology.

Premedical—Graduate Preparation Curriculum

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Biol. 1001			
Orientation to Biology	1-0-1	.....	.....
Biol. 2212			
Introductory Biology	.....	.....	4-3-5
Chem. 1111-2, 2113			
General Chemistry	4-3-5	4-3-5	3-3-4
Engl. 1001-2-3			
Introduction to Literature	3-0-3	3-0-3	3-0-3
Math. 1307-8-9			
Calculus I, II, III	5-0-5	5-0-5	5-0-5
Electives¹			
Physical Education	0-4-1	0-4-1	0-4-1
Electives^{2,6}			
Free	.....	3-0-3	.....
Totals	13-7-15	15-7-17	15-10-18

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Biol. 2210-1			
Introductory Biology	4-3-5	4-3-5	.....
Biol. 3332			
Biostatistics	.....	4-3-5	.....
Biol. 3335			
General Ecology	.....	.....	3-0-3
Engl.³ 2001-2-3			
Survey of the Humanities	3-0-3	3-0-3	3-0-3
Electives⁴			
Modern Language or Social Science	3-0-3	.....	6-0-6
Electives⁶			
Free or Technical	3-0-3	.....	.....

Chem.⁵ 3311-2-3			
Organic Chemistry	3-0-3	3-0-3	3-0-3
Chem. 3381-2			
Organic Chemistry Laboratory	.....	0-6-2	0-6-2
Totals	16-3-17	14-12-18	15-6-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
Biol. 3310			
General Microbiology	3-6-5	.....	.....
Biol. 3330			
Cell Physiology	4-3-5	.....	.....
Biol. 3334			
Genetics	.....	3-3-4	.....
Physics 2121-2-3			
Introductory Physics	4-3-5	4-3-5	4-3-5
Electives⁴			
Modern Language or Social Science	3-0-3	3-0-3	3-0-3
Electives⁶			
Free or Technical	.....	X-X-5	X-X-9
Totals	18	17	17

Senior Year

The minimum total number of credit hours required for a bachelor's degree in biology is 200. In addition to the required courses and electives of the freshman, sophomore and junior years, the 46 hours of free and technical elective courses required to complete the curriculum for the bachelor's degree may be taken in the senior year.

¹ See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

² These free elective courses may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, then it should be scheduled beginning the first quarter the student is enrolled.

³ Engl. 2004 or 2007 may be substituted for Engl. 2003.

⁴ Six three-hour social science courses or modern language courses acceptable for social sciences credit (see "Humanities and Social Sciences Requirements") are required. It is recommended that at least two courses be taken in a single social sciences area, e.g. history, philosophy and history of science, etc., and at least three courses be completed in a given language.

⁵ Chem. 3511 (biochemistry) may be substituted for Chem. 3313 (organic chemistry).

⁶ Of the 66 hours of free and technical electives indicated above, 43 hours must be departmentally approved technical elective courses in biology, chemistry, mathematics, physics or engineering. At least 20 of these hours must be biology course offerings. All technical electives must be chosen in conference with a faculty adviser to provide a meaningful, interrelated group ancillary to a specific field of interest. The other 23 hours are free electives. Not more than nine hours of free electives in the junior and senior years may be advanced ROTC.

School of Chemistry

Established in 1906

Director—J. Aaron Bertrand; *Assistant Director*—James A. Stanfield; *Regents' Professors*—Eugene C. Ashby, William H. Eberhardt, Hermann A. Flaschka; *Seydel-Woolley Professor*—Herbert O. House; *Julius Brown Professor*—Erling Grovenstein, Jr.; *Professors*—Raymond F. Borkman, Edward M. Burgess, Drury S. Caine III, Ronald H. Felton, Richard W. Fink, Sidney L. Gordon, Charles L. Liotta, George A. Miller, Thomas F. Moran, Henry M. Neumann, Robert A. Pierotti, James C. Powers, Peter E. Sturrock, Donald J. Royer, Nai-Teng Yu, Leon H. Zalkow; *Associate Professors*—E. Kent Barefield, Richard F. Browner, James L. Gole, Harold R. Hunt, Sheldon May, James C. Powers, Peter B. Sherry.

General Information

Included in the school are courses in chemistry required for various engineering and science curricula; for students interested in medical school; for the degree of Bachelor of Science in Chemistry; for graduate work leading to the degrees of Master of Science in Chemistry, Master of Science in Nuclear Science and Doctor of Philosophy in Chemistry.

Undergraduate Program

The degree Bachelor of Science in Chemistry will be awarded upon the completion of the following prescribed curriculum of which 63 quarter hours are elective work. A prerequisite for senior courses is a minimum grade point average of 2.0 in the following courses: Chem. 3311, 3312, 3313, 3381, 3382, 3385, 3411, 3412, 3413 and 3481.

The significant number of free elective hours in the chemistry curriculum permits one to make necessary concentrated elective work to achieve certificate programs in written and oral communications, foreign languages, social sciences, and other available programs of the Institute. In addition interdisciplinary minor options in geochemistry and T-4 certification (in association with Georgia State University) are also possible. The wise and judicious use of these free electives also enable the student to achieve considerable knowledge of other disciplines at Georgia Tech such as chemical engineering, physics, mathematics, management, textiles, ceramics, and biology. Too, these electives enable those who are interested in medical and dental schools to meet admission requirements of these schools.

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Chem. 1111-2 General Chemistry	4-3-5	4-3-5	.....
Chem. 2113 Chemistry Principles	.....	.....	3-3-4
Math. 1307-8-9 Calculus, I, II, III	5-0-5	5-0-5	5-0-5
Engl. 1001-2-3 Introduction to Literature	3-0-3	3-0-3	3-0-3
Elective Elementary German ¹ or Social Science	3-0-3	3-0-3	3-0-3
Elective⁶ Physical Education	0-4-1	0-4-1	0-4-1
Electives² Free	2-0-2	2-0-2	2-0-2
Totals	17-7-19	17-7-19	16-7-18

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Chem. 3311-2-3 Organic Chemistry	3-0-3	3-0-3	3-0-3
Chem. 3381-2-5 Organic Chemistry Laboratory	0-6-2	0-6-2	0-12-4
Math. 2307 Calculus	5-0-5	.....	.....
Math. 2308 Calculus and Linear Algebra	.....	5-0-5	.....
Phys. 2121-2-3 Physics	4-3-5	4-3-5	4-3-5
Electives³ Free	.....	.....	3-0-3
Totals	12-9-15	12-9-15	10-15-15

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
Chem. 3411-2-3 Physical Chemistry	3-0-3	3-0-3	3-0-3
Chem. 3481 Physical Chemistry Laboratory	.....	0-6-2	.....
Chem. 3111-2 Inorganic Chemistry	.....	4-0-4	4-0-4
Chem. 4211 Instrumental Analysis I	3-6-5	.....	.....
Engl. 2001-2-3 Survey of the Hu- manities	3-0-3	3-0-3	3-0-3
Electives³ Free	5-0-5	5-0-5	6-0-6
Totals	14-6-16	15-6-17	16-0-16

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
Chem. 4401 Physical Chemistry	3-0-3	.....	.....
Chem. 3491 Physical Chemistry Laboratory	0-6-2	.....	.....
Chem.⁴ 4212 Instrumental Analysis II	.....	3-6-5	.....
Electives³ Free	12-0-12	6-0-6	10-0-10

Electives⁵

Chemistry	.....	5-0-5	5-0-5
Totals	15-6-17	14-6-16	15-0-15

¹ The School of Chemistry recommends that German be taken in the freshman year. However, if social science is taken in the freshman year then German must be taken later.

² These free elective courses may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, ROTC should be scheduled the first quarter the student is enrolled.

³ Electives, free: of the total free electives in the chemistry curriculum, at least 18 hours of social science, selected from the College of Sciences and Liberal Studies listing in "Information for Undergraduate Students," must be taken.

⁴ May be taken in the junior year.

⁵ A total of 10 quarter hours in elective chemistry courses are required of which a minimum of four hours and a maximum of six hours must be from laboratory electives. These laboratory electives may consist of:

- two laboratory courses, 0-6-2 each,
- one laboratory course, 0-6-2 and Chem. 4901, 4902 or
- Chem. 4901, 4902, 4903.

Options b and c must have the approval of the school.

Chemistry electives may consist of Chem. 3511 or those numbered 4xxx, 6xxx, or other courses approved by the school; however Chem. 4201, 4701 and 4741 may not be offered as chemistry electives.

Registration for courses 6xxx and above must have school approval.

⁶ See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

Graduate Programs

The School of Chemistry also offers programs for both the master's and doctoral degrees in the fields of analytical, biochemistry, inorganic, nuclear, organic and physical chemistry.

The requirements for the master's degree are satisfied by the completion of an accepted program of 33 quarter hours of coursework plus an original research thesis of master's level. The nature of the course work, though it may be largely or totally in chemistry, is determined after consultation

with the student by his advising committee, and is designed to suit the needs and objectives of the individual.

The doctoral program is directed toward the goal of greater proficiency and depth in the chemical area with particular emphasis being placed on original, independent and scholarly research. The only course work demanded is the Institute requirement of a minimum of 15 earned credit hours in a minor field which may be any field of study chosen by the student in consultation with his advisor. The area need not necessarily be beyond the broad area of chemistry. Most students, however, do take a number of courses during their studies beyond the minor requirements. The numbers of such other courses vary with individuals, the major field interests, previous background, as well as long range goals.

Active research fields include: biophysical chemistry, Brillouin spectra, carbanion chemistry, catalysis, natural products chemistry, electron transfer reactions, enzyme chemistry, modern analytical and instrumental methods of analysis, mass spectrometry, mechanisms of organic, biological, and inorganic reactions, molecular spectra and structure, nuclear chemistry, laser chemistry, nuclear magnetic resonance, organic synthesis, organo-metallic chemistry, photochemistry, quantum mechanics, radioactive exchange reactions, structures of complex organic and inorganic compounds, surface phenomena, theoretical chemistry and thermodynamic properties.

Additional information regarding graduate work may be obtained by writing to the Director, School of Chemistry, Georgia Institute of Technology, Atlanta, Georgia 30332.

Department of English

Department Head and Professor—Karl M. Murphy; *Assistant Head and Associate Professor*—Robert E. Wood; *Professors*—Milton Chaikin, Annibel Jenkins, Samuel C. Ketchin, L. Hugh Moore, William B. Mullen, Helen H. Naugle, Larry J. Rubin, James D.

Young; *Associate Professors*—James J. Bynum, Elizabeth Evans, Irving F. Foote, Sarah E. Jackson, Matthew C. O'Brien, Esta K. Seaton, James P. Smith, Maxine T. Turner; *Assistant Professors*—Barbara W. Aba-Mecha, Alan R. Armstrong, Edith H. Blicksilver, Rand E. Bohrer, May C. Brown, Wister J. Cook, Richard J. Corbin, Ethel W. Githii, Roger A. Hambridge, David C. Leonard, Peter J. McGuire, Jeffrey D. Plank, Sara M. Putzell, Robert P. Reno, John S. Russell, Robert L. Snyder, Jay P. Telotte, Cynthia B. Thomiszer, James P. Thompson; *Lecturers*—Jean B. Cheney, Margaret Duckworth, Annie L. Farish, Gwen S. Fletcher, Patrice Gray, Julie M. Johnson, Ted M. Jones, Sherron Martinez, Catherine Smith, Lorraine Viscardi, Carol Wilson.

General Information

At the freshman-sophomore level the Department of English offers a six-quarter series of courses devoted to the study of language and literature and to intensive practice in composition. The freshman courses stress the relationship between content and form; the sophomore courses emphasize the humanistic values of literature in Western culture. The practice in composition stresses logical thinking, proper organization of material, effective use of evidence, and clarity and precision of expression.

The department also offers elective courses in both written and oral communication and in literature and language. The courses in communication include practical training in public speaking and in various kinds of writing that are useful in science, business and industry. The electives in literature cover a variety of approaches: major writers since the Renaissance studied in the scientific and philosophical context of their times, types of literary form, thematic approaches and seminars in individual writers. Credit in drama is granted for participation in productions of DramaTech, the student drama club.

Because of the great need for architects, engineers, industrial managers and scientists who are especially skilled in professional communication, the department

offers a program leading to a Certificate in Technical and Business Communication. This certificate is awarded upon completion of Engl. 3008, 3015, 3019, 3023 and 3024 with at least a C grade. The order of these courses can be varied, except that 3015 must be taken before 3019 and 3023 must be taken before 3024. Attainment of this certificate qualifies the student for positions requiring a high level of ability in written and oral communication. Detailed information about this program may be obtained from the English department office.

A special two-year program in the English language, composition and American literature is offered for students whose native language is other than English. Four of these courses—Engl. 1033, 2031-2-3—are classified as courses in the humanities.

Students who score sufficiently high on the Advanced Placement Examination administered by the College Entrance Examination Board are given credit for certain freshman-sophomore courses. A number of students in units whose curricula do not require Engl. 1001-2-3 and whose scores on the College Board SAT-Verbal and the English Achievement examinations are sufficiently high are given the option of waiving one or more of the freshman courses as prerequisites to enrollment in the upper-level courses offered by the department.

School of Geophysical Sciences

Established in 1970

Director and Professor—Charles E. Weaver; *Professors*—Julius Chang (Adjunct), Paul Crutzen (Adjunct), D. D. Davis, F. Einaudi, G. W. Grams, C. G. Justus, C. S. Kiang (Associate Director), Douglas K. Lilly (Adjunct), David W. Menzel (Adjunct), R. G. Roper, Herbert L. Windom; *Associate Professors*—Larry P. Atkinson (Adjunct), Kevin C. Beck, Jackson O. Blanton (Adjunct), Anton M. Dainty, Demetrius Lalas (Adjunct), L. Timothy Long, Robert P. Lowell, G. Lafayette Maynard (Adjunct),

Charles O. Pollard, Jr., Ronald G. Prinn (Adjunct), J. Helmut Reuter, Gordon Wallace (Adjunct), J. M. Wampler; *Assistant Professors*—Eric V. Eslinger (Adjunct), James L. Harding (Adjunct), Barry Huebert (Adjunct), Jean-Claude Mareschal; *Supporting Faculty*—W. V. Conn, James Erwin, J. I. Metcalf, Lin Pollard.

General Information

The School of Geophysical Sciences offers graduate study programs for those interested in understanding the earth and man's physical environment. The programs lead to the degrees Master of Science and Doctor of Philosophy. The term geophysical sciences is used in the broadest sense to include both physical and chemical studies of the earth, its waters and its atmosphere. Special emphasis is given to studying man's modification of the environment. Through joint research with engineers, students can relate their basic scientific studies to the solution of environmental problems.

Persons with a bachelor's degree in geology, meteorology, atmospheric science, chemistry, physics, mathematics, biology or engineering may be admitted to the graduate program. Individual programs of study will be tailored to each student's background and interests.

Present areas of specialization include geophysics, geochemistry, mineralogy, sedimentology, environmental geology, atmospheric dynamics, atmospheric physics and atmospheric chemistry. Interdisciplinary studies can be carried out in such areas as crystallography (crystal physics), geohydrology, engineering geology, nuclear geochemistry, organic chemistry, environmental studies and energy-meteorology relationships.

Research and study in oceanography are conducted in cooperation with the staff of the Skidaway Institute of Oceanography at Savannah, Georgia. Many of the staff members from both institutions hold joint appointments. Students desiring to do so may spend a significant portion of their time at Skidaway.

Undergraduate Program

The geophysical sciences are multidisciplinary with a strong dependence on the basic physical sciences, engineering and mathematics; therefore, undergraduate students interested in the geophysical sciences should work toward a bachelor's degree in one of these disciplines. An undergraduate enrolled in another Georgia Tech school may develop a substantial background in the geophysical sciences by proper choice of electives within his or her own degree program. For example, a specific set of upper-level courses is recommended for physics majors who are interested in geophysics.

A certificate program is available for students who desire formal recognition of their having taken a systematic series of courses in the geophysical sciences. Certificates are available for course work in three areas: geochemistry, geophysics and engineering geology. Detailed listings of the requirements for these certificates are available in the office of the School of Geophysical Sciences.

A student may elect to pursue an undesignated bachelor of science degree under the direction of the faculty of the School of Geophysical Sciences.

Master's Degree Programs

Graduate study will be tailored to the background and interests of each student entering the School of Geophysical Sciences. In order to pursue the courses which may be accepted as part of a graduate study program in geophysical sciences, most students will need a background which includes introductory geology and a minimum of one year of university-level courses in mathematics, chemistry and physics. Some remedial work without graduate credit will be required of students who enter without this background.

In order to qualify for the degree Master of Science in Geophysical Sciences, a student must have completed a specific set of undergraduate courses in geophysical sciences. In addition, most students in geologically oriented areas of study will be required to complete, if they have not al-

ready done so, a geological field study. Such students will be identified by the faculty at the beginning of their program. Completion of an approved thesis is required of all students who are to be awarded the degree Master of Science in Geophysical Sciences.

Students who wish to include more course work in a special technical area may be permitted to pursue a program of study which does not meet all the requirements for the designated master's degree. Such a program of study, approved by the faculty of the school, will lead to the degree Master of Science.

Graduate students in the School of Geophysical Sciences can qualify under the Multidisciplinary Program in Mineral Engineering by electing certain mining and minerals courses (see the section "Multidisciplinary Programs in Engineering" under the description of the College of Engineering in this catalog).

Doctoral Program

Persons with a strong background in the basic sciences and mathematics, who show a capability for high achievement in research in the geophysical sciences, may enter a program of study leading to the doctoral degree. A wide range of individual programs are available, owing to the multidisciplinary nature of the geophysical sciences. The program of study for candidates in some fields will require completion of a supervised geological field study.

School of Information and Computer Science

Established in 1963

Director—Raymond E. Miller; *Professors*—Lucio Chiaraviglio, Philip H. Enslow, Jr., James Gough, Jr., Morris D. Prince (Adjunct), Vladimir Slamecka, Pranas Zunde; *Associate Professors*—Albert N. Badre, Richard A. DeMillo, Nancy A. Lynch, Philip

J. Siegmann, Robert M. Siegmann (Adjunct), Frank Tsui (Adjunct); *Associate Professor—Librarian*—Frances E. Kaiser; *Assistant Professors*—Phillip L. Crews, John J. Goda, Jr., Nancy D. Griffith, Richard J. LeBlanc, Jr.; *Lecturers*—Jill T. Lawrence (Adjunct), Gary A. Gabriele (Adjunct), Stephen R. Ratzel (Adjunct), Alan H. Wells (Adjunct).

General Information

The goal of the discipline of information and computer science is to enhance the problem-solving ability of man's mind by designing information processing automata and systems and delegating to them some of the functions of the human mind. During the last decade the use of computers has become indispensable in science, engineering, management, education and other professions. Many believe that in the near future information processing will become the nation's largest industry, and that its disciplines will be centrally important to society.

Georgia Tech's School of Information and Computer Science reflects this growth and potential. It was established in 1963 with the sponsorship of the National Science Foundation. Today the school is one of the largest graduate departments of the Institute and is among the largest computer science schools in the United States. It offers the bachelor's, master's and doctoral degrees in information and computer science for professional and research careers in many areas of specialization.

I.C.S. students have free access to the school's laboratories. These include a computer systems laboratory (which houses five PRIME 400s, three IBM Series 1's, a large PDP 11/45, a PDP 11/20, a GT-40, and a wide array of special information processing devices), a computer design laboratory and a human information processing laboratory. Other computing resources available to students of the school are the CYBER 70-Model 74-28 and CDC 6400 computers in the Georgia Tech Office of Computing Services.

Details of the academic and research programs of the school are described in brochures available upon request.

Undergraduate Program

The undergraduate program, established in 1972, leads to the designated degree of Bachelor of Science in Information and Computer Science. It provides comprehensive education in information and computer science and is hospitable to multidisciplinary career objectives. The program has two primary directions. The first is the acquisition of marketable knowledge and skills for professional careers in areas such as computer and communication systems design, programming systems and languages and information systems design. The second direction prepares students for graduate work in information and computer science.

A total of 193 credit hours are required for graduation. The 42 hours of electives include 24 hours of course work in the areas of curricular emphasis.

Freshman Year

<i>Course</i>	<i>1st Q.</i>	<i>2nd Q.</i>	<i>3rd Q.</i>
I.C.S. 1000 Information and Society	1-0-1	.....	.....
I.C.S. 1001 Computing Facilities	.....	0-3-1	.....
I.C.S. 1116 Introduction to Linguistics	.....	.....	3-0-3
I.C.S. 1400 Introduction to Algorithms and Computing	.....	.....	2-3-3
Engl. 1001-2-3¹ Analysis of Literature	3-0-3	3-0-3	3-0-3
Math. 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
Electives² Laboratory Science	4-3-5	4-3-5	.....
Electives³ Physical Education	0-4-1	0-4-1	0-4-1
Electives⁴	2-0-2	2-0-2	2-0-2
Totals	15-7-17	14-10-17	15-7-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
I.C.S. 2150 Introduction to Discrete Structures	3-0-3	.....	.....
I.C.S. 2250 Technical Information Resources	1-0-1	.....	.....
I.C.S. 2400 Computer Programming	2-3-3	.....	.....
I.C.S. 2600 Computer Organization and Programming	.....	3-0-3	.....
I.C.S. 3113 Information Structures and Processes	.....	.....	3-0-3
Econ. 2000-1⁵ Principles of Economics I, II	.....	3-0-3	3-0-3
Math. 2307 Calculus IV	5-0-5	.....	.....
Math. 2308 Calculus V	.....	5-0-5	.....
Phys. 2121 Particle Dynamics	4-3-5	.....	.....
Phys. 2122 Electromagnetism	.....	4-3-5	.....
Phys. 2123 Optics and Modern Physics	.....	.....	4-3-5
Electives⁶ Humanities or Social Science	.....	.....	6-0-6
Totals	15-6-17	15-3-16	16-3-17

Junior Year

Course	1st Q.	2nd Q.	3rd Q.
I.C.S. 3140 Introduction to Discrete Systems	3-0-3	.....	.....
I.C.S. 3150 Introduction to Mathematical Logic	.....	3-0-3	.....
I.C.S. 3155 Introduction to Theory of Computing I	.....	.....	3-0-3

I.C.S. 3342

Intro. to Computational Linguistics

..... 3-0-3

I.C.S. 3422

Survey of Programming Languages

3-0-3

I.C.S. 3600-1

Computer Systems I, II

3-0-3 3-0-3

I.C.S. 3610

Computer Logic Design

..... 3-0-3

Math. 3215

Problems in Probability and Statistics

..... 5-0-5

Psy. 3303-4⁵

General Psychology A, B

..... 3-0-3 3-0-3

Electives⁶

Humanities or Social Science

3-0-3

Electives⁷

3-0-3 3-0-3 3-0-3

Totals

15-0-15 17-0-17 15-0-15

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
I.C.S. 4120-1 Intro. to Information Processes I, II	.....	3-0-3	3-0-3
I.C.S. 4155 Introduction to Theory of Computing II	3-0-3	.....	.....
I.C.S. 4300 Information Systems	3-0-3	.....	.....
Electives Humanities or Social Science	.....	3-0-3	3-0-3
Electives⁴	9-0-9	9-0-9	9-0-9
Totals	15-0-15	15-0-15	15-0-15

¹ These courses apply toward satisfaction of the 18 hour humanities requirement stated in "Information for Undergraduate Students."

² This requirement may be met by scheduling CHEM 1101 and CHEM 1102 or Biology 1710, 1711 and 1712. Hours for Biology in excess of 10 may be used for free electives.

³ All students are required to satisfactorily complete three credit hours in physical education courses. Unless medically disqualified, all stu-

dents will be required to complete swimming (P.E. 1010) plus two additional courses. One of these must be selected from the remaining courses at the 1000 level and one must be selected from the 2000 level. Students who are medically exempt from any single P.E. course must take another course at that level to substitute for the exempted course. Only students who are medically exempt from all "activity" P.E. courses may satisfy the requirement with P.E. 1040. Students who are 25 years of age or older upon matriculation have the option of completing the regular P.E. requirement or using P.E. 1040 to satisfy the requirement. A maximum of three credit hours of physical training may be applied toward the bachelor's degree.

⁴ Free elective courses to be taken at any time during the course of study. If basic ROTC is selected to satisfy these six credit hours, it must be scheduled beginning the first quarter of the freshman year. Six hours of basic ROTC and nine hours of advanced ROTC may be used as elective credit toward the bachelor's degree.

⁵ These courses apply toward satisfaction of the 18 hour social sciences requirement stated in "Information for Undergraduate Students."

⁶ Electives will include six hours of social sciences and nine hours of humanities. See "Information for Undergraduate Students," for electives which satisfy this requirement for the College of Sciences and Liberal Studies.

⁷ Electives in the junior and senior years will include 24 credit hours in two of the several areas of specialization recommended and approved by the school.

Professional Graduate Program

The objective of this graduate program is to offer career education terminating with the degree Master of Science in Information and Computer Science. Graduates of this professional program qualify for senior technical and management careers in information processing.

To earn the master's degree, students must complete at least 50 quarter hours, of which a minimum of 35 must be in courses at the 6000-8000 level and attain at least a 2.7/4.0 grade point average. A master's thesis, equivalent to 17 credit hours of graduate course work, is required of all students holding a bachelor's degree in information and computer science from the Georgia Institute of Technology (or a comparable degree from another institution). Students holding undergraduate degrees in

quantitative fields other than computer science such as mathematics, the physical and natural sciences or engineering need not write a thesis. The program begins in the fall quarter and its flexible curriculum draws on over 30 graduate-level courses in information and computer science.

Students applying for admission to the professional master's degree program must have earned a bachelor's degree from an accredited institution. While the undergraduate major is not specified, the prospective student's preparation should include substantial work in mathematics, at least through calculus, differential equations, set theory and introductory probability and statistics. Computing competence of the entering students should include higher level and assembly language programming, data structures, and computer systems hardware and software. Students having weaker backgrounds are expected to take the course work necessary to meet admission requirements.

Doctoral Program

The doctoral program in the School of Information and Computer Science prepares exceptionally qualified individuals for research, academic and policy-level management careers. The degree of Doctor of Philosophy is awarded by the Georgia Institute of Technology for conducting an original study resulting in a significant contribution to the discipline's body of knowledge.

The doctoral program normally requires at least three years effort. The first year of residence is devoted to the student's formal preparation in the foundations of the discipline and its branches, his or her demonstration of creative problem solving and a commitment to one of the major areas of the discipline as a research domain. The second phase of the doctoral program stresses continued study and research leading to the formulation of a thesis project. Thesis research and the dissertation defense complete the doctoral program.

Students applying for admission to the doctoral program should offer evidence of exceptional scholastic ability, intellectual

creativity and research motivation. Preferable undergraduate preparation includes computer science, mathematics or other disciplines of science or engineering that encourage mathematical formalisms and experimental methodology. The students are assumed to be competent in the use of computers.

Research Opportunities

Involvement in the school's active research efforts is an important part of a student's education. One such effort, a many-faceted study of fully distributed processing systems, is supported by projects on decentralized control, interprocess communication, task distribution, portability by means of abstract machines, development of an appropriate abstract-based programming language and theory with emphasis on modeling, performance measurement and analysis of algorithms. Other on-going projects involve program testing, complexity theory, design of software engineering tools for microprogramming, human factors aspects of interactive computing, natural algorithms in human problem solving, development of intelligent systems that plan, infer, learn and understand natural language, knowledge-based systems, global communications facilities for technology transfer, measures of information, empirical foundations of information science, information systems, and optimal utilization of information resources.

Elective Mini-Curricula

Computing competence is an indispensable skill for many professions; consequently, quality education in science, engineering and management increasingly emphasizes formal instruction in computing. The School of Information and Computer Science offers all Georgia Tech students, regardless of major, elective course sequences in computing designed to support the objectives of their future professions.

Four elective mini-curricula are offered for undergraduate students: computing for science and engineering, computing for in-

dustrial management, computer systems and information systems.

The core of these mini-curricula consists of four courses which emphasize digital computer organization, computer programming, data structures and information processing.

The first two mini-curricula serve students interested in the application of information processing and computing techniques to their respective field of knowledge or profession; the last two should appeal to students having deeper interest in applied information and computer science and those who may be leaning towards graduate work in this field. Detailed course schedules are available from the School of Information and Computer Science office.

Information and computer science is an appropriate minor field of study for the doctoral students of the Institute. Graduate students majoring in other departments of the Institute are encouraged to formulate, in consultation with their advisers and I.C.S. faculty, programs of study that include formal training in computing tailored to their educational objectives.

School of Mathematics

Established in 1952

Director and Professor—Les A. Karlovitz; *Assistant Director and Professor*—John C. Currie; *Assistant Director and Associate Professor*—Dar-Veig Ho; *Assistant Director and Associate Professor*—Alan D. Sloan; *Regents' Professor*—Marvin B. Sledd; *Professors*—William F. Ames, Johan G. F. Beilinfante, Bertram M. Drucker, James V. Herod, Eric R. Immel, William J. Kammerer, Robert H. Kasriel, Gunter H. Meyer, John D. Neff, Daniel A. Robinson, Michael P. Stallybrass, James W. Walker; *Associate Professors*—Michael F. Barnsley, George L. Cain, Jr., Nathaniel Chafee, Stephen G. Demko, Richard A. Duke, Donald M. Friedlen, Edgar Goodaire (visiting), Jamie J. Goode, Roger D. Johnson, Stanley E. Jones (visiting), Robert P. Kertz, John P. Line, Albert L. Mullikin, James M. Osborn,

Ronald W. Shonkwiler, William R. Smythe, Jr., M. Carl Spruill, Frank W. Stallard; *Assistant Professors*—Israel Aharoni (visiting), Alfred D. Andrew, Emmanuel N. Barron, Marc Berger, Mark J. Christensen, Jeffrey Geronimo (visiting), William L. Green, Andrew N. Harrington, Theodore P. Hill, Kenneth B. Howell (visiting), William F. Moss, Jack R. Pace (visiting), Gregory B. Passty (visiting), Marci Perlstadt (visiting), Kevin T. Phelps, John Piepenbrink, E. Juanita Pitts, Jonathan E. Spingarn, Dickenson Taliaferro (visiting), Michael B. Tamburro, Nicholas J. Weyland, Stephen Zemyan (visiting); *Instructors*—Virginia Jory, Pierre Vuillermot.

General Information

Mathematics forms an integral part of the curricula of most students at Georgia Tech. Consequently the School of Mathematics offers a wide range of courses serving students in the various engineering, science and management disciplines. In addition, the school offers programs of study leading to the bachelor's, master's and doctoral degrees in mathematics. Such programs of study serve as preparation for mathematical careers, professional schools and graduate studies.

In addition to basic courses in mathematics, the school offers a variety of specialized courses at the undergraduate and graduate levels, emphasizing areas related to the research activities of the faculty. At present these include mathematical analysis, applied mathematics, differential equations, scientific computing, probability, statistics, combinatorics, mathematical physics, topology and algebra.

The School of Mathematics has excellent computer facilities which are used in conjunction with an increasing number of courses and programs of study.

A cooperative plan for students who wish to combine practical experience with academic work is expected to begin for mathematics majors with the 1980-1981 academic year.

Information supplementary to this catalog which may be useful to students planning or considering a program of study in

mathematics is available in the school office.

Undergraduate Program

Reflecting the scientific environment at Georgia Tech, the bachelor's program in mathematics trains students in the traditional core mathematics curriculum, as well as in its applications. The program is sufficiently flexible to permit students to concentrate on some area of specialization, thus assuring depth as well as scientific breadth. In many areas, including Scientific Computing, Engineering Oriented Applied Mathematics, Optimization and Industrial Mathematics, and Mathematical Physics, the concentration is achieved through appropriate choices of electives in the junior and senior years. Information regarding the contents as well as professional and scientific goals of the various concentrations is available in the school.

In addition, the School of Mathematics offers a formal program for a concentration in Probability/Statistics. This program provides background specialization for professional careers in business, industry and government where statisticians and probabilists are needed, as well as for graduate study in a variety of fields. The curriculum requirements for this concentration are listed following those of the general program. It should be noted that this concentration retains at its core the courses of the general program. There is an increasing emphasis on the use of the electronic computers for computation, graphics and simulation throughout the undergraduate mathematics curriculum.

No more than six hours of physical education course work may be counted toward graduation. Only free electives in the degree program may be taken under the pass/fail option and no more than 12 hours are allowed under this option.

In addition to the institutional requirement of at least a 2.0 grade point average for the entire academic program, the School of Mathematics requires a 2.0 grade point average in all mathematics courses at or above the 3000 level which are designated by number in the program.

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Math. 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
Engl. 1001-2-3 Literature	3-0-3	3-0-3	3-0-3
Elective Chem. 1101-2 or 1111-2, General Chemistry	4-3-5	4-3-5	.....
Phys. 2121 Particle Dynamics	.....	.....	4-3-5
Electives Free	3-0-3	3-0-3	3-0-3
Elective¹ Physical Education	0-4-1	0-4-1	0-4-1
Totals	15-7-17	15-7-17	15-7-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Math. 2307-8 Calculus IV, V	5-0-5	5-0-5	.....
Math. 3308 Differential Equations	.....	.....	5-0-5
Elective I.C.S. 1700 or E.E. 1010, Introduction to Com- puter Programming	2-3-3	.....	.....
Math. 3110 Introduction to Higher Algebra	.....	3-0-3	.....
Math. 3215 Probability and Statis- tics	.....	.....	5-0-5
Phys. 2122 Electromagnetism	4-3-5	.....	.....
Phys. 2123 Optics, Modern Phys- ics	.....	4-3-5	.....
Elective Humanities/Social Science/ Modern Language	3-0-3	3-0-3	3-0-3
Elective Free	.....	.....	3-0-3
Totals	14-6-16	15-3-16	16-0-16

Junior and Senior Years

1. Math. 4101, 4301, 4311, 4312, 4313, 4320	23 hours
2. Phys. 3121	5 hours
3. Course work at or above the 3000 level in a degree-granting school other than mathematics	6 hours
4. Mathematics courses at or above the 4000 level, including at least two sequences and subject to the following restrictions: (a) At least 12 hours, including a sequence, shall be chosen from (i) probability, statistics and sto- chastic processes; (ii) differential equations; (iii) numerical analysis and optimization; and (iv) mathematical models. (b) Not all the courses in (a) shall come from the same area. (c) Math 4391 and 4392 may not be included	21 hours
5. Humanities and social science courses. The degree program must include either a year sequence in a modern language, or nine hours of English beyond Eng. 1001- 2-3	24 hours
6. Free electives	18 hours
Total	97 hours

¹ See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

Junior and Senior Years for the Concentration in Probability/Statistics

1. Math 4101, 4301, 4311, 4312, 4313, 4320	23 hours
2. Physics 3121	5 Hours
3. Either Math 4220, 4221, 4282, 4222 or 6232, 4225, 4230, 4241 (emphasis in probability); or Math 4220, 4230, 4241, 4242, 4251, 4245, 4281 or 6261 (emphasis in statistics)	21 hours
4. Electives: Technical electives, in applied probability/statistics courses at least at the upper undergraduate level, outside the School of Mathematics; selected on approval of the School of Mathematics	6 hours
5. Electives: Technical electives, either in (a) an- other applied mathematics area, at 4000 level or higher, or in (b) other areas where probability/statistics is applied, such as in modeling, data analysis, case studies (upper undergraduate level); se- lected on approval of the School of Mathematics	6 hours

6. Humanities/social science courses. The degree program must include either a year sequence in a modern language or nine hours of English beyond English 1003	18 hours
7. Electives: Free	18 hours
Total	97 hours

Graduate Programs

The School of Mathematics provides op-
portunities for study in a wide range of
mathematical disciplines. First year gradu-
ate sequences are offered in algebra,
analysis, differential equations, numerical
analysis, probability and topology. In addi-
tion, courses are available in methods of
applied mathematics.

A program of study should include analy-
sis consisting of Math. 6310, 6320, 6330
and at least one of the modelling courses:
Math. 6510, 6520 or 6530. In addition, six
hours of course work at the 3000 level or
higher should be taken outside of the
School of Mathematics. The program
should also include either a thesis (17
hours) and seven additional hours of
course work at the 4000 level or higher or
24 hours of course work at the 4000 level
or higher, including nine hours of concen-
tration in some field of mathematics, three
hours in numerical analysis and three
hours in probability, statistics or stochastic
processes (provided that the student has
not previously had such training) and a suf-
ficient number of hours at the 6000 level or
higher to insure that the program includes
a total of at least 35 hours at this level.

A grade point average of at least 2.7 in
the mathematics courses in the program of
study and a grade of C or better in each
mathematics course in the program of
study are required.

Before admission to candidacy for the
master's degree, each student must pass
an oral comprehensive examination.

Most applicants holding the bachelor's
degree are urged to enter the master's de-
gree program before seeking admission to
the doctoral program.

Prospective candidates for the doctoral
degree are required to complete 77 hours
of course work beyond the undergraduate

degree. Of these 77 hours at least 30
hours must be taken in certain specified
areas of mathematics including those sub-
jects required for all students in the
master's degree program. Fifteen of the 77
hours must be taken outside the School of
Mathematics and constitute the student's
minor field of study.

A grade of C or better is required in each
course to be counted toward the total of 77
credit hours and a grade point average of
2.7 is required in the minor courses.

Prior to admission to candidacy for the
doctoral degree, each student must pass
comprehensive examinations in each of
four areas of mathematics selected in part
by the student.

Doctoral candidates must demonstrate a
reading knowledge of two languages cho-
sen from French, German and Russian,
and satisfy the Institute requirements with
respect to the dissertation and final oral ex-
amination.

Department of Military Science

Established in 1917

Professor and Head—Lieutenant Colonel
David B. Garvin; *Assistant Professor*—Ma-
jor Michael A. Canavan, Captains David L.
Bikus, John C. Carson, Herman M. Smith,
Charles W. Stewart, Jr.

General Information

The purpose of the Army officer education
program is to provide well educated lead-
ers and decision makers for service as
commissioned officers in the Army of the
United States.

The program was developed to foster
understanding of the Army role in national
security and society; to provide a perspec-
tive of the officer's responsibility within that
environment; and to provide the leadership
and military management education re-
quired to function effectively in a competi-
tive, highly technical, dynamic decision-
making environment. Commissions are

awarded upon graduation. Newly commissioned officers are ordered to active duty involving aviation, engineering, research and development, electronics-communications, or other selected specialties.

A graduate choosing a non-military career may be awarded a commission in the Reserve Forces with service in the vicinity of civilian employment. The Department of Military Science offers instruction in both the two-year and the four-year programs. The four-year program consists of the basic course and the advanced course, each of two years duration. The two-year program is open to both undergraduate and graduate students who may enter the advanced course directly after attending a six week basic camp in lieu of the basic course. The two-year program is also open to students who qualify for exemption from the basic course as a result of prior military service, adequate participation in a Junior ROTC program in high school or compression at Georgia Tech.

Students who have met the above requirements for the basic course or its equivalent may be selected by the professor of military science for entry into the advanced course if they demonstrate leadership potential, pass qualifying exams and have six academic quarters remaining. Once selected to the advanced course, the student must meet course requirements including attendance at a five week advanced camp and acceptance of a commission, if offered. Students in the advanced course are given a tax free subsistence allowance of up to \$1000 per year and are paid while attending the five week advanced camp at the rate of one-half the basic pay of a second lieutenant. Active duty may be delayed to pursue an advanced degree. ROTC cadets who meet special requirements may apply for a commission in the regular army.

Army ROTC College Scholarship Program

College scholarships are available to highly qualified students enrolled in the program. Competition is based on SAT or ACT scores, academic record, extracurricular

activities and leadership potential. Scholarships include full payment of tuition, fees, health services, text books and supplies, and up to \$1000 per year for a period not exceeding four years.

The Basic Course Curriculum

The basic curriculum consists of six military science courses selected from the following course offerings.

Course	Credit Hrs.
M.S. 0130¹ Ranger Company (1-1-0)	0
M.S. 1001 The Army of Today (2-1-1) —required first course	1
M.S. 1002 Army Operational Systems (2-1-1)	1
M.S. 1003 Terrain Analysis & Land Navigation (2-3-2)	2
M.S. 2001 Basic Military Leadership (2-1-1)	1
M.S. 2002 Analysis of Command & Leadership (2-1-2)	2
M.S. 2003 Applications of Leadership (1-2-2)	2
Total	9 ²

The Advanced Course Curriculum

The advanced curriculum consists of military science courses and three elective courses, one each in physical education, history and political science.³ The three elective courses may be taken at any time during the student's four years of study, but must be successfully completed for the student to receive credit for advanced course completion.

Course	Credit Hrs.
M.S. 3001 Advanced Military Navigation (2-3-3)	3

M.S. 3002 Tactical Decision-Making I (2-1-2)	2
M.S. 3003 Tactical Decision-Making II (2-1-2)	2
M.S. 4001 The Military Team and the Junior Officer (2-1-2)	2
M.S. 4031 Military Engineering (2-1-2)	2 ⁵
M.S. 4061 Tactical & Strategic Communications— Electronics Systems (2-1-2)	2 ⁵
M.S. 4002 Military Management (2-1-2)	2
M.S. 4003 Professional Ethics & the Army Officer (2-1-2)	1
Total	16 ^{4,5}

¹ Course is optional.

² A total of six hours of basic ROTC courses may be applied toward a degree.

³ P.E. (select one) 1010, 1020, 1030, 1050, 2090. Hist. (select one) 1001, 1002, 3010, 3012, 3024. Pol. Sci. (select one) 3203, 3204, 3205.

⁴ A total of nine credit hours of advanced ROTC courses may be applied toward a degree.

⁵ Cadet will choose one of 4001, 4031 or 4061.

Department of Modern Languages

Established in 1904

Professor and Head—Louis J. Zahn; *Professors*—James Gough, Jr., George F. Walker (Adjunct); *Associate Professors*—William M. Johnson, Karl T. Langenbruch, Heidi M. Rockwood; *Assistant Professors*—Jerry C. Brooks, Tatjana Gregory, Frank E. Humphreys III, Frederick H. Langhorst, Edmund B. Richmond, Maria S. Venable, Roy O. Wyatt; *Lecturers*—Nancy E. Arnow, Jane P. Bean, Janice H. Bos, Paula F. Einaudi, Elizabeth T. England, Fusun S. Ercan, Don A. Fischer, Edith D. Fusillo, Linda H. Grant, Mary E. Gring, Jill B. Harmer, Dempsey D. Horton, Cathleen C. Jacobson, E. Helen Jeroslow, Bruce A. Kahn, Jane A. Leonard, Maria E. Lewis, M.

Ann Mauney, Nicole B. Mills, Odette P. Morphy, Michael K. H. Nuedling, Agnes E. Robertson, Andrea H. Sander, Elizabeth Z. Sturrock, Carolyn T. Suzuki, Philip D. Wendkos, Arthur W. Wilhelm, Charles E. Windish.

General Information

The diverse course offerings of the Department of Modern Languages provide students with opportunities for achieving reasonable fluency in writing, reading, speaking and understanding several foreign languages including English as a foreign language. Further, they instruct students in the civilizations and literatures of the countries in which those languages are spoken.

Although the department does not offer a degree or "major," certificates or "minors" are available in French, German, linguistics and Spanish. Eighteen credit hours are required for a certificate in any of the four aforementioned options, fifteen hours of which must be on the 3000-level or above. Students should consult the department for additional details.

Students may take any courses for which they have the prerequisites as specified in the catalog descriptions. Counseling and placement examinations are available on request. Usually two years in high school equal one year at Tech. Each course is essentially a unit in itself, but beginning students are encouraged to pursue at least the elementary three-quarter sequence in order to achieve a minimum level of proficiency. Students are not permitted to enroll without departmental consent in 1000-level courses after the successful completion of any 2000, 3000 or 4000-level course. Students who take courses in their native language must schedule courses no lower in number than 3001.

Since 1000 and 2000-level courses are usually offered each quarter in French, German and Spanish, co-ops should not encounter difficulty in scheduling them. Since each course on the 2000, 3000 and 4000-level is a unit in itself, they do not have to be taken in numerical order.

With minor exceptions students can fulfill

their 36-hour humanities and social science requirements for graduation by taking courses, including linguistics courses, in the Department of Modern Languages. Students should consult the course catalog descriptions and the section of this catalog entitled "Humanities and Social Science Requirements" on p. 40, in order to determine which courses are classified as humanities and which are classified as social sciences in their respective colleges. With the approval of students' major departments any courses offered by the Department of Modern Languages may be taken on a pass/fail basis.

Engineering college students who choose to *begin* the study of a foreign language (1001-2-3) must take in addition at least three three-hour courses 2000-level or higher, if they wish to receive "humanities" credit for the 1000-level courses; otherwise those 1000-level courses will count as "elective" credit. All courses taken on the 2000-level count as "social science." Engineering college students should note that the aforementioned provision does *not* apply to Linguistics; all Linguistics courses on the 1000, 2000, and 3000-levels carry "humanities" credit both individually and collectively.

College Credit for High School Study

Nine hours of elective credit in French, German, Italian, Portuguese, and Spanish, or 12 hours in Russian will be granted for high school study in a foreign language provided the student has two or more years of high school credit (or the equivalent) in the language in question and has completed nine quarter hours at the 2000, 3000 or 4000-level with an average grade of "C" or higher. Transfer students must complete at least three of the nine hours at Georgia Tech.

Credit for high school study in a foreign language will not be granted to students who speak the language in question as their native language or to students who have taken 1000-level courses or the equivalent at Georgia Tech or at other col-

lege-level institutions from which they have received transfer credit.

To have this elective credit entered on their records, students must request that the appropriate form be submitted by the Department of Modern Languages to the registrar. This elective credit is not applicable toward fulfillment of the 36-hour social sciences and humanities requirements for graduation. No grade is attached to this credit.

Graduate Language Requirements

The Department of Modern Languages currently serves the Institute by providing training in foreign languages and by administering, during each quarter of the regular academic year, the foreign language examinations that are among the options for satisfying the foreign language requirement of the Graduate Division. This training is available to all undergraduate and graduate students through the 1001-2-3 series of courses in the various disciplines offered by the department. It is also available to all graduate students, to all upper divisional undergraduates and—with the consent of the department—to exceptional lower divisional undergraduates, through the following five series of courses:

- Fren. 4075-6-7—Intensive Readings in French,
- Ger. 4075-6-7—Intensive Readings in German,
- Russ. 4075-6-7—Intensive Readings in Russian,
- Span. 4075-6-7—Intensive Readings in Spanish and
- Ling. 4075-6-7—Comparative Analysis of Major European Languages.

For additional information, see page 55.

English for Foreign Students

The department also serves the Institute by providing instruction in English as a foreign language, offered through non-credit programs in intensive English for foreign students (elementary, intermediate and

advanced levels) usually under the auspices of the Department of Continuing Education. The prerequisite is two years of high school English or the equivalent. Included in the program are grammar, pronunciation, sentence patterns, vocabulary building, spelling, reading, theme writing and group and individual practice in the language laboratory. These intensive courses of 25 hours per week are offered during all four quarters. Pursuant to specific requests, special programs and schedules are developed and offered to complement programs of study in engineering and science.

The department also offers a series of three credit courses, Linguistics 1001-2-3, which provides foreign undergraduates with an opportunity to perfect their English and acquire nine hours of humanities credit toward graduation.

For further information write to Dr. Louis J. Zahn, Department of Modern Languages, Georgia Institute of Technology, Atlanta, Georgia 30332.

Department of Music

Department Head and Director of Choral Activities—Gregory Colson; *Director of Bands*—Kenneth Durham; *Conductor of the Jazz Ensemble*—Ronald Mendola.

General Information

Musical activities at Georgia Tech center around three enthusiastic and well-known performing groups: Band, Chorale and Jazz Ensemble. The Band meets three afternoons a week, the Chorale and Jazz Ensemble meet twice a week and all three organizations give academic credit. Planning is done with awareness of other demands upon Tech students so that a great amount of musical experience is concentrated into a limited time.

The Marching Band is known nationally as a result of its smart formations and dynamic sound in television performances at both bowl and regular season football games and trips for out-of-town games pro-

vide an extra reward for members. As a change of pace, during the winter and spring quarters the Concert Band studies and performs a broader instrumental repertory with emphasis on basic theory, contrasting musical styles and periods, as well as baton technique of student conductors.

The Chorale, an eighty-voice singing group which combines the well-known men's glee club with the newer women's chorus, undertakes an ambitious series of classical, sacred and popular-music performances on campus, in the Atlanta area and in neighboring states on a spring-break tour. They are featured in concerts of sacred masterworks with members of the Atlanta Symphony and in Pops concerts with combos and the Jazz Ensemble. The thorough-going approach to music history, theory and vocal technique allows Chorale members to earn humanities credit.

The Jazz Ensemble, although new at Georgia Tech, has shown tremendous growth and has established a strong reputation through numerous local appearances. After meeting the prerequisite of a satisfactory audition, members are involved in rehearsals, lectures and discussions, listening sessions and performances, resulting in a wide background of theory, history and literature within the jazz idiom.

Department of Naval Science

Established in 1926

Commanding Officer and Professor of Naval Science—Captain George M. Henson, USN; *Associate Professor*—Commander Charles E. Hill, USN; *Assistant Professors*—Major U. S. Grant, USMC; Lieutenant Jay A. Dragon, USN; Lieutenant William J. Willkie, USN; Lieutenant John A. Stockton, USN; Lieutenant Keith R. Larson, USN; Lieutenant David D. Pruett, USN.

General Information

The naval officer education program offers students the opportunity to qualify for ser-

vice as a commissioned officer in the U.S. Navy or U.S. Marine Corps. The program consists of a standardized curriculum designed to complement and assist academic pursuits by imparting knowledge of the naval environment and fostering an understanding of the role of the Navy and Marine Corps in national security. Upon graduation, the student is commissioned and ordered to active duty involving flying, nuclear propulsion, surface warfare or to a staff specialty.

Students in the program are enrolled in one of the three categories outlined below. An orientation period for all new NROTC students is conducted during registration week prior to the fall quarter.

Scholarship Students

Scholarship students are appointed midshipman, USNR, after nationwide competition. They have their tuition, fees and textbooks paid for by the Navy for a period not exceeding four years, are uniformed at government expense and receive retainer pay at the rate of \$100 per month. Students must obligate themselves to complete the prescribed naval science curriculum, to make a cruise of from six to eight weeks each summer, to accept a commission as Ensign, USN, or Second Lieutenant, USMC, upon graduation, and to serve on active duty for four years after commissioning unless released earlier by the Navy Department. At the end of this period their active duty obligation to the Navy or Marine Corps is fulfilled. If they do not desire to remain on active duty in the regular Navy or Marine Corps, they are ordered to inactive duty in the Navy or Marine Corps Reserve.

College Program Students

College program students are enrolled under the provision of Public Law 88-647. The college program can be entered during the freshman year or, upon qualification, prior to April 1 of the sophomore year. Qualified sophomores attend eight weeks of active duty schooling during the summer before their junior year so they can join their classmates on an equal footing in the

junior year naval science classes. Prior to starting the junior year, the college program student is required to enlist in the U.S. Naval Reserve for a period of six years. The student must agree to serve on active duty for not less than three years after appointment to commissioned rank in the U.S. Naval Reserve or Marine Corps Reserve and to retain that commission until the sixth anniversary of receipt of original commission.

College program students are uniformed at government expense and, during their junior and senior years, receive retainer pay of \$100 per month. They must complete the prescribed naval science curriculum, make a cruise of approximately six weeks during the summer after the junior year, and upon graduation accept a commission as Ensign, USNR or Second Lieutenant, USMCR. If they desire, after receiving their reserve commission college program students may apply for a commission in the regular Navy or Marine Corps.

All college program students are under constant consideration for award of a scholarship. Sophomore students who attend the eight weeks of schooling during the summer before their junior year may be awarded a scholarship on the basis of superior performance during schooling.

Naval Science Students

Any regularly enrolled undergraduate student may enroll as a naval science student. Those enrolled as naval science students take naval science courses as electives and have no contract with the Navy. They have no assurance of ultimate commissioning nor do they derive any of the financial benefits available to scholarship and college program students.

Selection Procedure

Scholarship students are selected in nationwide competition based on SAT or ACT scores. The NROTC at Georgia Tech has no part in this selection although information about the scholarship program is available.

The professor of naval science may an-

nually nominate several college program students to the Chief of Naval Education and Training for a scholarship. To apply for the college program, a student must be enrolled at Georgia Tech or attending an accredited college or university in the near vicinity and be at least 17 and not over 21 years of age. Applicants are selected to fill the quota based on physical qualifications, interview by naval officers, score on SAT and high school record. Applicants for the college program should apply at the Naval Armory during the designated days of freshman orientation week for the fall quarter.

Curriculum

In addition to the required naval science courses, all Navy Option Scholarship Students must take calculus (Math. 1307-9 or Math. 1711-3), physics (Phys. 2121 or 2141 series) and if not majoring in engineering, math, physics or chemistry, one course from I.C.S. 1700, Phys. 2122 or Phys. 3141. All marine option students must take Pol. 3203 and Pol. 3204 or a substitute approved by the professor of naval science.

No more than six hours of credit in basic naval science courses and no more than nine hours of credit in advanced naval science courses will be applied toward a degree.

Department of Physical Education and Recreation

Established in 1942

Department Head and Professor—James A. Reedy; *Associate Professors*—Bill D. Beavers, Byron A. Gilbreath, John C. Hyder, James H. McAuley, Tommy Plaxico; *Assistant Professors*—Carlos E. deCubas, James P. Culpepper, Jr., Douglas L. Fowlkes, David W. Houser; Phillip B. Sparling.

General Information

The Department of Physical Education and Recreation seeks to provide opportunities to develop new skills and gain information that will allow the student to lead a healthier and more productive life. Students who have completed their physical education requirement are encouraged to elect additional courses of interest.

The majority of activity and skills courses are scheduled on two alternate days per week, meeting two hours per day.

The Physical Education Requirement

All students entering Georgia Tech are required to satisfactorily complete three credit hours of physical education courses. It is expected that this requirement will be completed during the student's freshman year. Unless medically disqualified, all students will be required to complete swimming (P.E. 1010) plus two additional courses. One of these must be selected from the remaining courses at the 1000 level, and one must be selected from the 2000 level.

The health information record will determine any medical exemptions from physical education courses. All certificates of disability from personal physicians must be endorsed by the Student Health Services before they will be accepted by the department.

Students who are exempt for medical reasons from all physical education activity courses will be required to satisfactorily

complete P.E. 1040 (Health Education) to complete their physical education requirement. Students who are medically exempt from a single 1000-level course including swimming must substitute an additional 1000-level course in its place.

Transfer students will be granted credit for comparable physical education courses completed at other institutions.

Students who are 25 years of age or older upon matriculation to the Institute have the option of satisfying the physical education requirement for graduation by completing the regular physical education requirements or by satisfactorily completing P.E. 1040.

School of Physics

Established in 1939

Interim Director and Regents' Professor—Charles H. Braden; *Regents' Professors*—Joseph Ford, Harold A. Gersch, Earl W. McDaniel, L. David Wily; *Professors*—R. Martin Ahrens, Helmut Biritz, Christopher Bottcher (Adjunct), Harold R. Brewer, David Finkelstein, Martin R. Flannery, Ronald F. Fox, Ian R. Gatland, Don S. Harmer, Uzi Landman, David W. Martin, Elliott W. Montroll (Adjunct), Eugene T. Patronis, Jr., Edwin J. Scheibner, Augustus L. Stanford, James R. Stevenson, Edward W. Thomas, Jr., Henry S. Valk, Thomas L. Weatherly, Michael K. Wilkinson (Adjunct), J. Quitman Williams, R. A. Young; *Associate Professors*—Harry G. Dulaney, David B. Dusenbery, William G. Harter, Nisbet S. Kendrick, Donald C. O'Shea, James M. Tanner, Roger M. Wartell, LeRoy A. Woodward, William E. Woolf; *Assistant Professors*—Charles L. Cleveland, David L. Fuller (Adjunct), Richard S. Hanni, James C. Martin, Richard M. Williamon (Adjunct); *Lecturer*—Barbara Levi.

General Information

Physics has been known primarily as a basic science, and fundamental research into the principles of physics continues to occupy the attention of many physicists. But

the study of physics has also become increasingly important as a basis for fundamental research in interdisciplinary areas such as biophysics and chemical physics and as an applied science in government and industry. Furthermore, as society becomes more technically oriented, an education in physics may provide an advantageous pre-professional foundation.

The School of Physics offers basic service courses to freshmen and sophomores, some advanced service courses for students of engineering, science or mathematics, and advanced work leading to the bachelor's, master's and doctoral degrees in physics. The school seeks to provide elective freedom in its undergraduate and graduate degree programs in order to enable students with a wide variety of interests to work out suitable programs of study.

In addition to offering courses in the fundamentals of physics, the school provides numerous specialized courses at the undergraduate and graduate levels, especially in areas related to the research interests of the faculty. Current faculty research interests include acoustics, atomic physics, computer science, elementary particles, general relativity, many-body theory, molecular physics, nuclear physics, quantum logic, solid-state physics, statistical mechanics, physics instruction and interdisciplinary areas in biophysics and materials science. Opportunities exist in these areas, as well as in some other areas by collaboration with faculty members of other departments, for undergraduate and graduate special problems, master's theses and doctoral dissertations.

Information supplementary to this catalog that may be useful to students in the planning of programs of study is available from the School of Physics. A graduate brochure which further describes the opportunities for graduate study and research is available upon request. Students majoring in physics are urged to consult frequently with their faculty advisers. Any student who has not been assigned an adviser should contact the departmental office.

Undergraduate Programs

The School of Physics offers two undergraduate degrees, the Bachelor of Science in Physics and the Bachelor of Science in Applied Physics. The basis of the former degree program is the traditional preparation of a student for graduate study in physics. The degree program in applied physics may be better suited for entry into industry or government upon graduation, preparation for further professional training (medicine, law, dentistry or business) or preparation for graduate study in some other discipline. The two degree programs differ in that a few courses intended primarily as preparation for graduate study in physics in the traditional program are replaced by courses oriented toward the applications of physics in the applied physics program. Greater flexibility in the choice of technical electives is available in the applied physics program.

Each of the baccalaureate programs contain: (a) courses needed to meet general institutional degree requirements, (b) a core of technical courses intended to give a strong background in mathematics and in the physical principles of mechanics, electricity and magnetism, thermodynamics and the quantum theory which governs physical phenomena at the microscopic level of molecules, atoms and nuclei, (c) technical electives which enable the student to explore areas of his or her choice in greater depth and (d) free electives, about one quarter of the total hours, which may be employed to schedule additional technical or nontechnical courses.

The considerable flexibility inherent in the physics curricula is advantageous to students who wish to work out individual programs of study. At the same time, this flexibility suggests the need for consultation with advisers in order that good use may be made of the elective hours and in order to avoid scheduling difficulties that may arise in later quarters.

Many students who earn a degree in physics have transferred from another discipline. The degree programs have been planned to enable most students to transfer into physics with little or no loss of credit.

A total of 190 credit hours is required for the bachelor's degree in physics. A grade point average of at least 2.0 in physics courses numbered 3000 and higher is a requisite for the degree.

Bachelor of Science in Physics Curriculum

Freshman Year^{7,8,9}

Course	1st Q.	2nd Q.	3rd Q.
Math. 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
Chem. 1101-2¹ General Chemistry	4-3-5	4-3-5	.....
Phys. 2121² General Physics	.....	.....	4-3-5
Engl. 1001-2-3³ Analysis of Literature	3-0-3	3-0-3	3-0-3
Electives^{4,5} Social Science or Humanities	3-0-3	3-0-3	3-0-3
Electives⁶ Physical Education	0-4-1	0-4-1	0-4-1
Totals	15-7-17	15-7-17	15-7-17

Sophomore Year⁸

Course	1st Q.	2nd Q.	3rd Q.
Math. 2307-8 Calculus IV, V	5-0-5	5-0-5	.....
Math. 2309¹⁰ Differential Equations	.....	.....	5-0-5
Phys. 2122-3 General Physics	4-3-5	4-3-5	.....
Electives^{4,5} Social Science	3-0-3	3-0-3	3-0-3
Electives^{4,5} Humanities or Social Science	3-0-3	3-0-3	3-0-3
Electives⁹	.....	.....	6
Totals	15-3-16	15-3-16	11-0-17

Junior and Senior Years

Course	Credit Hrs.
Phys. 3121-2-3 Classical Mechanics and Electricity and Magnetism (5-0-5 each)	15
Phys. 3141 Thermal Physics	5

Phys. 3143 Quantum Mechanics I	5
Electives Physics electives which must include at least three laboratory courses. These electives must be approved by the School of Physics and must not include more than six hours below the 3000 level.	20
Electives To bring total hours to 190.	45
Total, junior and senior years	90

Footnotes are listed following the program for the Bachelor of Science in Applied Physics.

Bachelor of Science in Applied Physics Curriculum

Freshman Year^{7,8}

Course	1st Q.	2nd Q.	3rd Q.
Math. 1307-8-9 Calculus I, II, III	5-0-5	5-0-5	5-0-5
Chem. 1101-2¹ General Chemistry	4-3-5	4-3-5	.....
Phys. 2121² General Physics	.....	.....	4-3-5
Engl. 1001-2-3³ Analysis of Literature	3-0-3	3-0-3	3-0-3
Electives⁴ Social Science or Humanities	3-0-3	3-0-3	3-0-3
Electives⁵ Physical Education	0-4-1	0-4-1	0-4-1
Totals	15-7-17	15-7-17	15-7-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Math. 2307-8 Calculus IV, V	5-0-5	5-0-5	.....
Math. 2309¹⁰ Differential Equations	.....	.....	5-0-5
Chem. 2113¹¹ Chemical Principles	.....	.....	3-3-4
Phys. 2122-3 General Physics	4-3-5	4-3-5	.....
E.Gr. 1170¹³ Introduction to Visual Communication	.....	2-3-3	.....
Electives¹² Computer Programming	.....	.....	0-0-3

Electives⁴ Social Science	3-0-3	3-0-3	3-0-3
Electives⁴ Humanities or Social Science	3-0-3	3-0-3	3-0-3
Totals	15-3-16	17-6-19	14-3-18

Junior and Senior Years

Course	Credit Hrs
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Phys. 3133
Mechanics

Phys. 3134
Electromagnetism

Phys. 3138 or 3143
Quantum Theory

Phys. 3211
Electronics

Electives
Technical electives which must include at least three laboratory courses. These technical electives need not all be in physics but they must be approved by the School of Physics and must not include more than six hours below the 3000 level.

Electives
To bring total hours to 190.
Total, junior and senior years

¹ Students contemplating advanced work in chemistry should consider taking Chem. 1111-2 in lieu of Chem. 1101-2.

² Some students, e.g. biophysics students or premedical students, will find it advisable to commence upper level chemistry courses during their sophomore year. They should schedule Chem. 2113 in the third quarter of the freshman year and defer the start of the general physics sequence until the sophomore year.

³ Students whose scores on the College Board SAT-Verbal and the English achievement examinations are sufficiently high may, in consultation with the Department of English, replace courses in the Engl. 1001-2-3 sequence by other English courses.

⁴ See "Information for Undergraduate Students" for information relative to the 36 credit hour requirement in the humanities and the social sciences.

⁵ It is recommended that students who contemplate doctoral work in physics include study of the French, German or Russian languages in their programs.

⁶ See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman

physical education requirements for both men and women.

⁷ If ROTC is elected, the first course should be scheduled during the first quarter the student is in attendance. A student may schedule additional hours during the freshman year, or certain courses may be deferred in order to schedule ROTC. A maximum of 15 hours of ROTC courses may be counted as free electives, toward a degree in physics, of which no more than six hours may be in ROTC courses at the 1000-2000 level.

⁸ It is recommended that physics majors elect Phys. 1000 during the freshman year.

⁹ A course in computer programming is suggested, during the freshman or sophomore years, e.g., I.C.S. 1700, C.E. 2502, E.E. 1010, M.E. 3016 or Phys. 3263.

¹⁰ Students who have demonstrated competence in mathematics should consider taking Math. 3308 in lieu of Math. 2309.

¹¹ Phys. 3141 or M.E. 3720 may be substituted for Chem. 2113; however, students who expect to take additional chemistry courses should schedule Chem. 2113.

¹² This requirement may be met by scheduling one of the following courses: I.C.S. 1700, C.E. 2502 (plus one additional elective hour), E.E. 1010, M.E. 3016, Phys. 3263 or other computer course approved by the School of Physics.

¹³ E.Gr. 1170 may be replaced by another course, with the approval of the student's academic adviser.

Use of Elective Hours

Students may utilize their elective freedom in the physics curricula to specialize in particular areas of physics, to prepare for careers in interdisciplinary areas of science, as a preprofessional program or to gain a background in other technical or nontechnical disciplines. For assistance to students in planning programs of study with emphasis directed towards a particular objective, the school has formulated suggestions for the use of elective hours. Supplementary material, available from the departmental office or from faculty advisers, includes suggestions relevant to the following areas of study: graduate study in physics, acoustics, applied optics, astrophysics-astronomy, biophysics, computer applications, geophysics, instrumentation-measurement, materials science, nuclear science, pre-business/management and premedical. A

candidate for either baccalaureate degree in physics need not follow any one of these suggested areas of study. Features of several programs may be combined or individual programs of study may be devised.

Attention is also directed to the possibility of using elective hours for special problems (Phys. 3900-1-2 or 4900-1-2) conducted under the supervision of a faculty member.

Graduate Programs

Master's Programs

The School of Physics offers two master's degrees, the Master of Science in Physics and the Master of Science in Applied Physics.

The Master of Science in Physics is the traditional physics degree and normally comprises the program that a graduate student executes in the course of study towards a doctorate. The requirements for the degree may be fulfilled on the basis of 50 hours of course work, or a master's thesis may be elected in lieu of 17 hours of courses. Although there are no rigid course requirements for the degree, most students are advised to include Phys. 6121, 6122, 6123 and 6141 and mathematics equivalent to Math. 4347-8-9 or Math 6511-12-13. A research component is recommended, either through inclusion of Special Problems work or by election of a thesis.

The Master of Science in Applied Physics is intended to help prepare an individual for a career in industrial, independent or government laboratories. It is a good choice for a terminal master's degree. However, the program may equally well serve as preparation for a doctoral program. The program includes a "practicum" of at least 12 credit hours in an area of applied physics. Examples of available areas include: acoustics, instrumentation (including small computer applications), optics, physical characterization of materials and physics instruction. Courses in the principles of physics of importance in applied physics are recommended (e.g., Phys. 4143, Phys. 6121 or 6131, Phys. 6122 or 6132, Phys. 4262, and mathematics equivalent to Math. 3110 and 4582). Addi-

tional courses in support of the practicum are recommended.

Doctoral Program

The Doctor of Philosophy degree is directed toward proficiency in independent scholarly work. The degree program comprises course work in the principles of physics, additional specialized courses both in the area of the doctoral thesis and in one or two other areas, demonstration of reading competence in a foreign language, the passing of a comprehensive examination and an independent research investigation.

Except for a requirement that 15 credit hours must be earned in a minor field, which may be any approved technical or nontechnical field that the student chooses in consultation with his adviser, there are no definite course requirements for the doctoral degree in physics. Most students find that they will schedule about 65 hours of courses and that completion of Phys. 8001-2-3, 6121-2-3 and 6141 is advisable prior to taking the comprehensive examination. Phys. 6143 and mathematics equivalent to Math. 6511-2-3 are recommended for most doctoral candidates. A grade point average of 2.9 in courses taken while a graduate student is required to register for the comprehensive examination and is a requisite for the degree.

Students are encouraged to commence participation in the departmental research programs early in their graduate careers. The undertaking of a doctoral thesis is usually reserved until the comprehensive examination is passed, which may occur during the second graduate year for a well prepared student.

School of Psychology

Established in 1959

Professor and Director—Edward H. Loveland; *Professors*—E. Jo Baker, M. Carr Payne, Jr., Edward J. Rinalducci, William W. Ronan; *Associate Professors*—Albert N. Badre, Terry L. Maple, M. Jackson Marr, Stanley A. Mulaik, Charles V. Riche, Ander-

son D. Smith, C. Michael York; *Assistant Professors*—J. Neil Bohannon, Gregory M. Corso; *Lecturers*—Scarvia B. Anderson, O. Edmund Martin.

General Information

The School of Psychology serves a dual function in the Institute. First, it offers training in the basic and applied aspects of the science of behavior for the student majoring in architecture, engineering, industrial management and natural sciences. It also offers programs of study leading to the Bachelor of Science in Applied Psychology, and the Master of Science and Doctor of Philosophy in Psychology.

The undergraduate curricula in psychology stress fundamentals, providing opportunity for broad training in mathematics, the natural sciences, humanities, social sciences and management. The large number of elective courses enables each curriculum to fulfill a wide variety of educational and vocational needs. Graduates have been able to engage successfully in postgraduate study in many fields including business administration, history, industrial management, labor relations, law, medicine, music, psychology and theology.

The program provides excellent preparation for graduate work in psychology and is especially adaptable to premedical education. Graduates of the program also have been employed successfully in a variety of positions relating to personnel subsystems (including human engineering), personnel research, personnel service, systems development, management and the administration of business, engineering and health programs.

Undergraduate Curricula

In order to serve the diverse educational needs of students who enter the Institute, the School of Psychology offers three curricula leading to the degree Bachelor of Science in Applied Psychology. All three curricula options require 193 quarter hours.

Curriculum I provides maximum freedom to the student in building his or her course of study. Of the 193 quarter hours required

for the degree only 91 hours are designated by course number. This option offers a choice of several chemistry or physics course sequences from among which the student elects one sequence in one of the two sciences. It offers the student the choice of two course sequences to satisfy the one-year basic mathematics requirement. Seven required psychology courses form a core around which the student, with the assistance of his or her adviser, builds his or her psychology major.

Curriculum II is technically oriented and stresses quantitative and experimental approaches to the study of behavior. Approximately 60 percent of the graduates of this curriculum have continued their studies in psychology graduate programs, medical and law schools, as well as in other graduate programs leading to degrees in such widely diverse fields as business, education, history, labor relations, marketing, music and religion. Other graduates have been employed upon graduation in a variety of positions including general management, personnel research, personnel services (e.g. personnel training and employment), personnel subsystems (including human factors engineering), engineering psychology research and systems engineering.

Both Curricula I and II lend themselves to a special program intended to prepare students to teach behavioral science at the high school level. Through a cooperative arrangement with Georgia State University, interested students may enroll for required education courses at that institution while working toward their bachelor's degree at Georgia Tech. Upon completion of the program the student will be eligible to apply for a T-4 teaching certificate.

Curriculum III was developed to provide opportunities for those students who wish to combine a major in psychology with study of a coherent minor in linguistics and languages. This curriculum can provide a base for graduate study in linguistics and in those areas of psychology relating to the study of language. It can be particularly useful to those who seek postgraduate em-

ployment in positions involving work with cultural groups in which linguistic problems exist as significant variables in education or vocational preparation.

Curriculum I

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Chemistry or Physics¹	4-3-5	4-3-5	.....
Engl. 1001-2-3 Introduction to Literature	3-0-3	3-0-3	3-0-3
Math. 1307-8-9² Calculus I, II, III	5-0-5	5-0-5	5-0-5
Electives³ Modern Language or Social Science	3-0-3	3-0-3	3-0-3
I.C.S. 1700 Digital Computer Programming	.....	.....	2-3-3
Electives⁴ Physical Education	0-4-1	0-4-1	0-4-1
Electives⁵ Free	2-0-2	2-0-2	2-0-2
Totals	17-7-19	17-7-19	15-7-17

Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
Engl. 2001-2-3 Survey of Humanities	3-0-3	3-0-3	3-0-3
Biol. 1710-11-12⁶ Principles of Biology	3-3-4	3-3-4	3-3-4
Psy. 3303-4 General Psychology	3-0-3	3-0-3	.....
Psy. 4401 Industrial Psychology	.....	.....	3-0-3
Electives Psychology	.....	.....	3-0-3
Electives⁷ Free	6-0-6	6-0-6	3-0-3
Totals	15-3-16	15-3-16	15-3-16

¹ One complete sequence of chemistry courses (Chem. 1101-2 or Chem. 1111-2) or one complete sequence of physics courses (Phys. 2111-2-3 or 2121-2-3 or 2141-2-3). Hours in

excess of 10 may be used for elective credit.

² Math. 1711-2-3 may be substituted.

³ Choice of (1) two quarters of one of the following: American history, political science, philosophy and history of science, or sociology, with the third quarter selected from one of the three remaining areas, or (2) three quarters of one modern foreign language. Students electing modern language courses which total more than nine hours may use the excess hours for free elective credit.

⁴ See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

⁵ These free elective courses may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, ROTC should be scheduled the first quarter the student is enrolled.

⁶ Biol. 2210-11 and 2 hours of electives may be substituted.

⁷ A total of not more than nine hours of electives may be in advanced ROTC.

Junior and Senior Years

A total of 193 quarter hours is required for the degree. During the junior year, students will complete Math. 3710, Psy. 4403, 4406 and 4407. During the junior and senior years, students will complete Psy. 4410 and Engl. 3015. Twenty-seven hours of psychology electives are required in the curriculum, three in the sophomore year and 24 in the junior and senior years. At least one course must be selected from each of the following four areas:

Area I: Psy. 4411, 4412* and 4413
Area II: Psy. 4400, 4421, 4422, 4423, 4754
Area III: Psy. 4402, 4424, 4750
Area IV: Psy. 4404, 4405, 4409.

*The student should be aware that Psy. 4412 is a prerequisite to Psy. 4413.

Curriculum II

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
Chem. 1101-2 General Chemistry	4-3-5	4-3-5	.....
I.C.S. 1700 Digital Computer Programming	2-3-3

Engl. 1101-2-3

Introduction to Literature	3-0-3	3-0-3	3-0-3
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Math. 1307-8-9

Calculus I, II, III	5-0-5	5-0-5	5-0-5
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Electives¹

Modern Language or Social Sciences	3-0-3	3-0-3	3-0-3
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Electives²

Physical Education	0-4-1	0-4-1	0-4-1
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Electives³

Free	2-0-2	2-0-2	2-0-2
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Totals	17-7-19	17-7-19	15-7-17
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Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
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Engl. 2001-2-3

Survey of the Humanities	3-0-3	3-0-3	3-0-3
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Math. 2307

Calculus IV	5-0-5
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Math. 2308

Calculus and Linear Algebra	5-0-5
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Biol. 2210-1

General Biology	4-3-5	4-3-5
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Psy. 3303-4

General Psychology	3-0-3	3-0-3
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Psy. 4401

Industrial Psychology	3-0-3
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Electives⁴

Free	3-0-3	6-0-6
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Totals	15-3-16	15-3-16	15-0-15
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Junior Year

Course	1st Q.	2nd Q.	3rd Q.
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Math. 3710

Introduction to Statistics	5-0-5
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Psy. 4403

Introduction to Psychological Testing	3-0-3
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Psy. 4405

Seminar in Organizational Psychology	3-0-3
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Psy. 4406

Psychological Statistics	2-3-3
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Psy. 4407

Experimental Psychology I	2-3-3
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Psy. 4410

Social Psychology	3-0-3
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Phys. 2121-2-3

Physics	4-3-5	4-3-5	4-3-5
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Electives

Free	3-0-3	3-0-3	6-0-6
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Totals	15-3-16	13-6-14	16-9-17
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Senior Year

Course	1st Q.	2nd Q.	3rd Q.
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Psy. 4411

Experimental Psychology II	3-3-4
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Psy. 4412

Psychology of Learning	3-3-4
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Psy. 4413⁵

Applied Experimental Psychology	3-3-4
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Psy. 4814

Special Problems	0-3-1
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Psy. 4815

Special Problems	3-3-4
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Engl. 3015

Public Speaking	3-0-3
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Electives

Free	7-0-7	9-0-9	8-0-8
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Totals	13-3-14	12-6-14	14-6-16
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¹ Choice of (1) two quarters of one of the following: American history, political science, philosophy and history of science, or sociology, with the third quarter selected from one of the three remaining areas, or (2) three quarters of one modern foreign language. Students electing modern language courses which total more than nine hours may use the excess hours for free elective credit.

² See "Curricula and Degrees," Department of Physical Education and Recreation for freshman physical education requirements for both men and women.

³ These free elective courses may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, ROTC should be scheduled the first quarter the student is enrolled.

⁴ A total of not more than nine hours of electives may be in advanced ROTC.

⁵ Psy. 6602 may be substituted for Psy. 4413 with

the approval of the School of Psychology and dean of the graduate school.

Curriculum III

Freshman Year

Course	1st Q.	2nd Q.	3rd Q.
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Chemistry or Physics¹

	4-3-5	4-3-5
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Engl. 1001-2-3

Introduction to Literature	3-0-3	3-0-3	3-0-3
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Math. 1307-8-9

Calculus I, II, III	5-0-5	5-0-5	5-0-5
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I.C.S. 1700

Digital Computer Programming	2-3-3
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Electives²

Modern Language or Social Science	3-0-3	3-0-3	3-0-3
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Electives³

Physical Education	0-4-1	0-4-1	0-4-1
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Electives⁴

Free	2-0-2	2-0-2	2-0-2
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Totals	17-7-19	17-7-19	15-7-17
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Sophomore Year

Course	1st Q.	2nd Q.	3rd Q.
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Engl. 2001-2-3

Survey of Humanities	3-0-3	3-0-3	3-0-3
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Biol. 2210-11⁵

Principles of Biology	4-3-5	4-3-5
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Psy. 3303-4

General Psychology	3-0-3	3-0-3
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Psy. 4401

Industrial Psychology	3-0-3
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Electives

Modern Language	3-0-3	3-0-3	3-0-3
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Electives⁶

Free	3-0-3	3-0-3	5-0-5
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Totals	16-3-17	16-3-17	14-0-14
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Junior Year

Course	1st Q.	2nd Q.	3rd Q.
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Math. 3710

Introduction to Statistics	5-0-5
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Psy. 4400 Developmental Psychology	3-0-3
Psy. 4403 Introduction to Psychological Testing	3-0-3
Psy. 4406 Psychological Statistics	.....	2-3-3	.....
Psy. 4407 Experimental Psychology I	.....	.....	2-3-3
Psy. 4410 Social Psychology	.....	.....	3-0-3
Ling. 3302-3 Introduction to Structural Linguistics	.....	3-0-3	3-0-3
Electives⁷ Linguistics	3-0-3	.....	.....
Electives Modern Language	3-0-3	3-0-3	3-0-3
Electives Free	.....	3-0-3	3-0-3
Totals	14-0-14	14-0-15	14-3-15

Senior Year

Course	1st Q.	2nd Q.	3rd Q.
Psy. 4411 Experimental Psychology II	3-3-4	.....	.....
Psy. 4412 Psychology of Learning	.....	3-3-4	.....
Psy. 4423 Introduction to Psycholinguistics	.....	.....	3-0-3
Psy. 4814 Special Problems	.....	0-3-1	.....
Psy. 4815 Special Problems	.....	.....	3-3-4
Engl. 3015 Public Speaking	3-0-3	.....	.....
P.S.T. 3113 Symbolic Logic	3-0-3	.....	.....
Ling. 4002 Current Developments in Linguistics	.....	3-0-3	.....

Ling. 4003 Semantics and Linguistic Structure	.....	.....	3-0-3
Electives Linguistics	3-0-3	.....	.....
Electives Free	3-0-3	6-0-6	6-0-6
Totals	15-3-16	12-6-14	15-3-16

¹ One complete sequence of chemistry courses (Chem. 1101-2 or Chem. 1111-2) or one complete sequence of physics courses (Phys. 2111-2-3 or 2121-2-3 or 2141-2-3). Hours in excess of 10 may be used for elective credit.

² In addition to the Institute history and constitution requirements, this curriculum requires considerable modern language experience. The modern language requirement can vary from 15 to 21 hours. It consists of completing 21 hours in a single language or one upper level course in one language and one year of either Russian or Chinese as a second language.

³ See "Curricula and Degrees," Department of Physical Education and Recreation, for freshman physical education requirements for both men and women.

⁴ These free elective courses may be taken at any time during a student's course of study. However, if six credit hours of basic ROTC are elected, ROTC should be scheduled the first quarter the student is enrolled.

⁵ Biol. 1710-1-2 may be substituted.

⁶ A total of not more than nine hours of electives may be in advanced ROTC.

⁷ Six hours of linguistics electives are required.

Graduate Curricula

Doctoral and master's candidates share a core curriculum of required courses which include three proseminars in general psychology, nine additional course hours in psychology to be prescribed by the student's faculty advisory committee with the approval of the director of the School of Psychology and 18 hours to be chosen by the student, with the approval of his or her advisory committee, from among courses in psychology and other fields. Permission to substitute another course for a required course may be granted if the student can demonstrate competence in course content by passing a written examination. Doctoral

candidates are expected to complete all requirements for the master's degree including a thesis and a demonstrated reading proficiency in one foreign language.

The master's degree is viewed as a significant educational achievement in itself, and is not awarded routinely for completion of part of the doctoral program. Master's programs are intended to prepare the student for continuation of graduate work toward the Ph.D., for professional work in business, industrial, government or educational positions, or for both. The master's degree should require two calendar years for most students. A master's thesis is required.

The doctoral program provides the student with an opportunity for advanced study in general-experimental, industrial-organizational or engineering psychology. Each of these curricula consists of additional courses and programs of individual study and research beyond the core curriculum, which contribute to a strong background in general experimental psychology and the student's area of specialization. The doctoral program will ordinarily require four years for students who enter immediately after obtaining the bachelor's degree.

Admission to graduate study in psychology with full graduate standing in the School of Psychology requires the equivalent of an undergraduate major in psychology or a related field with courses in general and experimental psychology, psychological statistics, testing and measurement and either industrial psychology or social psychology. Supplementary education in such areas as biology, chemistry, physics, engineering, foreign languages and particularly mathematics is strongly advised. Students who have considerable undergraduate preparation in one or more of these areas may, with the approval of the School of Psychology, forego some of the required psychology courses. All applicants should submit scores on the Miller Analogies Test and the Graduate Record Examination.

The psychology faculty encourages competent students in subjects other than psychology to apply for admission.

School of Social Sciences

Established in 1948

Director—Daniel Papp; *Professors*—John C. Gould, Patrick Kelley, Melvin Kranzberg (Callaway Professor of History of Science and Technology), Morris Mitzner, Frederick A. Rossini, Willard E. Wight; *Associate Professors*—Ronald H. Bayor, James E. Brittain, Stanley R. Carpenter, Daryl E. Chubin, August W. Giebelhaus, Robert C. McMath, Jr., Daniel S. Papp, Germaine M. Reed, Sandra W. Thornton, Jay A. Weinstein, Dorothy C. Yancy; *Assistant Professors*—Victoria Durant-Gonzalez, Lawrence W. Foster, Timothy A. Hall, John J. Havick, John N. Hines, Jon J. Johnston, Thomas D. Philips, David H. Ray, Diana Velez.

General Information

The School of Social Sciences offers course work in history, philosophy of science and technology, political science and sociology. On one hand these subjects perform their vital traditional roles of helping the student cultivate a critical awareness and perspective on the perennial evaluative issues that confront man, both as an individual and as a member of a complex social order. On the other, they reflect upon and contribute to the resolution of the scientific and technological issues that are Georgia Tech's special province.

Certificate Programs in the Social Sciences

Seven certificate programs enable students to concentrate course work in areas of their particular interest. Each program is designed to possess thematic depth and unity and aims to meet two desirable student objectives: (1) the systematic acquisition of conceptual skills and perspectives that complement his or her professional major by enriching understanding of its social dimensions and cultural roots; and (2) strengthening the background of students planning graduate study in law, medicine, business, etc., by a systematically gained

competence in an area additional to one's major.

Four of the seven certificate programs are in the traditional disciplines of history, philosophy, political science and sociology. The remaining three programs cut across discipline lines to provide a foundation in international affairs, the interaction of science, technology and society, and urban studies.

Students interested in planning a certificate program in one of these areas should contact the School of Social Sciences for further information. A faculty adviser will be assigned to each student to plan a program of study to meet his or her needs and interests. Detailed information concerning these programs may be obtained in the Social Science office.

U.S. and Georgia History and Constitution Requirements

The state of Georgia requires all students to display a knowledge of U.S. and Georgia constitutions and U.S. and Georgia history.

To complete the requirement in U.S. and Georgia constitutions, a student must pass Pol. 1251 or 3200, or an examination on the U.S. and Georgia constitutions.

To complete the requirements in U.S. and Georgia history, a student must either pass Hist. 1001, 1002, 3010 or 3011, or pass an examination on U.S. and Georgia history.

Examinations for both requirements are administered each quarter (only to first quarter seniors) by the School of Social Sciences. Students who do not take the exams or who are unsuccessful must then take the appropriate course(s) prior to graduation.

Graduate Program in Technology and Science Policy

The M.S. program in the rapidly expanding field of technology and science policy is designed to train, in one to two years of study, professionals with technical and scientific backgrounds to identify and analyze policy issues emerging from technological

and scientific development in contemporary societies. Graduates may anticipate professional employment by agencies involved in the preparation of technology assessments and environmental impact statements, formulating corporate responses to governmental policies affecting energy and the environment, evaluating the effects of governmental and corporate policies affecting technological innovation, and dealing with problems of transferring technologies to developing nations.

The program includes an intensive 180-hour multidisciplinary core involving theory and both quantitative and qualitative methodology. It also requires an elective concentration of at least 15 hours, designed for the individual student's career needs, and a thesis. Where possible, the thesis requirement will place the student in an internship environment similar to anticipated professional employment.

The team-taught core curriculum and the small number of students per faculty member will bring the student into early and intensive contact with faculty members. The program's flexibility in elective and thesis requirements allows the student an opportunity to arrange a custom designed program.

Students applying for admission to the professional master's degree program must have earned a bachelor's degree from an accredited institution. It is strongly recommended that students have a bachelor's degree or strong undergraduate concentration in engineering or science with experience in statistics. However, well prepared students with other majors are also encouraged to apply.

COURSES OF INSTRUCTION

Course descriptions are listed alphabetically by schools and departments of instruction. The specific degree requirements for each curriculum at both the undergraduate and graduate levels are listed alphabetically by colleges in the section *Curricula and Degrees*.

Course numbers below 3000 are lower division (freshman and sophomore) courses. Those numbered 3000-4999 are designated as upper division (junior and senior) courses. They are open to students of the lower and upper divisions with the proper prerequisites and to graduate students on approval of the individual student's major school. Courses designed for graduate students are numbered 5000 and above; the methods of presentation and quality of work expected make them generally unsuited to undergraduate participation. An upper-division undergraduate student is therefore permitted to enroll in a graduate level course only after consultation with and approval of his or her major school and the dean of the graduate division.

Figures entered below the course number and title of each course signify the number of class hours per week, the number of laboratory hours per week and the quarter hours credit for the completed course, in that order. Thus, the entry 4-3-5 in Chem. 1101 means that the course meets for four lecture hours per week, has three hours of laboratory work per week and is evaluated at five quarter hours credit upon completion of the quarter's work.

AEROSPACE ENGINEERING

A.E. 1350. Introduction to Engineering 2-3-3.

Emphasizes creative imagination in engineering, rather than mathematics. The growth and behavior of biological systems are related to engineering problems.

A.E. 1750. Introduction to Bioengineering 3-0-3.

Introduction to aspects of science and technology pertinent to bioengineering. Also taught as E.E. 1750, E.S.M. 1750 and M.E. 1750.

A.E. 2101. Introduction to Aircraft Structures 4-0-4. Prerequisite: E.S.M. 2201. Prerequisite or corequisite: Math. 2308.

Introduction to elements of structural mechanics which are used in the design of aircraft and missile structures.

Text: *An Introduction to the Mechanics of Solids*, Crandall, et. al.

A.E. 2603. Computer Applications in Aerospace Engineering 1-6-3. Prerequisite: Math. 1309.

Description of the components of a modern digital computing system. Elementary FORTRAN programming. Introduction to aerospace engineering applications.

Text: at the level of Murrill and Smith.

A.E. 3000. Fluid Mechanics I 4-3-5. Prerequisite: M.E. 3322, 2.0 overall average and a 2.0 average in math and in physics. Prerequisite or corequisite: Math. 2309.

The atmosphere, fluid properties, classification of flows and one-dimensional flows including isentropic flows, normal shocks and duct flows with friction and heating.

Text: Shapiro, *Compressible Fluid Flow*, volume one.

A.E. 3001. Fluid Mechanics II

4-3-5. Prerequisite: A.E. 3000.

The physical equations for continuum flows and applications to laminar and turbulent boundary layers for incompressible and compressible flow.

Text: at the level of Kuethe and Schetzer, *Foundations of Aerodynamics*.

A.E. 3002. Fluid Mechanics III

4-3-5. Prerequisite: A.E. 3001.

Two-dimensional incompressible flow theory, superpositioning and conformal transformations, with applications to flow around bodies and to airfoil theory.

Text: at the level of Kuethe and Schetzer, *Foundations of Aerodynamics*.

A.E. 3103. Fundamentals of Stress Analysis

3-0-3. Prerequisite: A.E. 2101. Prerequisite or corequisite: Math. 2309.

Stresses in unsymmetrical bending. Deflections due to bending. Two dimensional problems in elasticity.

Text: *An Introduction to the Mechanics of Solids*, Crandall, et. al.

A.E. 3104. Energy Methods and Stability in Structures

3-0-3. Prerequisite: A.E. 2101. Prerequisite or corequisite: Math 2309.

Introduction to stability analysis with applications to columns and plates. Principle of virtual work and energy principles.

Text: at the level of Rivello, *Theory and Analysis of Flight Structures*.

A.E. 3110. Structures Lab

1-3-2. Prerequisite or corequisite: A.E. 2101.

Introduction to theory of measurements and to methods for determining mechanical properties.

Texts: *An Introduction to Mechanics of Solids*, Crandall, et. al. *Experimental Methods for Engineers*, Holman.

A.E. 3750. Introduction to Biofluid Dynamics

3-0-3. Prerequisite: Math. 2309, Phys. 2123.

Study of blood flow in the cardiovascular system, with emphasis on the modeling of such flows and the potential of flow studies for clinical research application. Also taught as E.S.M. 3750.

A.E. 4000. Fluid Mechanics IV

4-3-5. Prerequisite: A.E. 3002.

Finite wing theory, two-dimensional subsonic and supersonic compressible flows, supersonic flow around bodies of revolution and an introduction to transonics and hypersonics.

Text: at the level of Kuethe and Schetzer, *Foundations of Aerodynamics*.

A.E. 4100. Advanced Structures

3-0-3. Prerequisite: A.E. 3102 or consent of school.

Beam columns, shear webs with cut-outs, shear lag, bending in the plastic range, curved beams, miscellaneous thin metal structural problems.

A.E. 4101. Analysis of Thin-Walled Structural Elements

3-0-3. Prerequisite: A.E. 3103.

Torsion of non-circular solid cross sections. Bending of thin-walled open and closed section beams.

Text: at the level of Rivello, *Theory and Analysis of Flight Structures*.

A.E. 4102. Selected Topics in the Analysis of Aircraft Structures

3-0-3. Prerequisites: A.E. 3103 and A.E. 3104.

Selected topics from among the following: shear webs, shear lag, matrix methods, composite materials, fracture and fatigue, applications of virtual work principle, connections.

A.E. 4110. Structures Lab

1-3-2. Prerequisite: A.E. 3110; Prerequisites or corequisites: A.E. 3103, A.E. 3104.

Introduction to methods of experimental stress analysis on a variety of structural elements.

Text: *Experimental Methods for Engineers*, Holman.

A.E. 4200. Vibration and Flutter

3-0-3. Prerequisite: A.E. 3002, E.S.M. 4210. Prerequisite or corequisite: Math. 4582.

Structural dynamics of one-dimensional systems. Analyses of static aeroelastic phenomena and flutter. Equations of motion for complete aeroelastic system and solution techniques.

A.E. 4250. Jet Propulsion

5-0-5. Prerequisite: A.E. 4000.

The theory and principles of jet propulsion. The mechanics and thermodynamics of combustion. Component and cycle analysis. Engine performance characteristics.

Text: at the level of Hill and Peterson, *Mechanics and Thermodynamics of Propulsion*.

A.E. 4350-1. Aerospace Engineering Design Project I, II

2-6-4 each. Prerequisite: A.E. 4000. Prerequisite or corequisite: A.E. 4410, A.E. 4500.

Preliminary design or case study of an aerospace system such as a complete flight vehicle, a propulsion system, a structural system or a control system.

Text: at the level of Perkins and Hage, *Airplane Performance, Stability and Control*.

A.E. 4400. Introduction to Propeller and Rotor Theory

3-0-3. Prerequisite or corequisite: A.E. 4000 or consent of school.

A study of the theory and equations used in the design of propellers and helicopter rotors.

Text: at the level of Gessow and Myers, *Aerodynamics of the Helicopter*.

A.E. 4410. Vehicle Performance

3-0-3. Prerequisites: A.E. 3001, A.E. 3002. Prerequisite or corequisite: A.E. 4000.

A study of basic aerodynamic-vehicle performance including drag estimation, horsepower-thrust required and available, basic point and path performance; special performance items, maneuvers and resultant air loads.

A.E. 4500. Stability and Control

5-0-5. Prerequisite: A.E. 4000, E.S.M. 4210.

Principles of static lateral and longitudinal stability and studies of the equations and methods used in analysis. Applications to airplane and missile systems.

A.E. 4550. Instrumentation for Experimental Research I

2-3-3. Prerequisite: consent of school.

Laboratory treatment of major and ancillary instrumentation used in solid and fluid mechanics research, voltage, current, resistance measurement, transducers, amplifiers, oscilloscopes, recording equipment.

A.E. 4551. Instrumentation for Experimental Research II

2-3-3. Prerequisite: A.E. 4550 or consent of school.

Advanced treatment of laboratory instrumentation for research, analysis and application of operational amplifiers, filters and signal conditioners, elementary digital circuits, computer systems for data acquisition.

A.E. 4760. Engineering Acoustics and Noise Control I

3-0-3. Prerequisite: senior standing.

Study of acoustics related to noise and its control, acoustic terminology, wave propagation, solutions to the wave equation, instrumentation, sound field in large and small rooms, noise legislation. Also taught as E.S.M. 4760, M.E. 4760.

A.E. 4761. Engineering Acoustics and Noise Control II

3-0-3. Prerequisite: A.E. 4760 or equivalent.

Continuation of A.E. 4760 emphasizing techniques for the solution of noise problems. Vibration isolation, energy absorption, dissipative and reactive mufflers, enclosures, barriers, properties

of materials, panel damping. Also taught as E.S.M. 4761, M.E. 4761.

A.E. 4770. Structural Integrity and Durability

3-0-3. Prerequisites: E.S.M. 3301 or A.E. 2101.

Simple stress-concentration problems involving plastic deformation, residual stresses, hysteresis, creep and relaxation. Introduction to fatigue and fracture mechanics. Crack-growth calculations and wearout models.

A.E. 4803-13-23-33-43-53. Special Topics

3-0-3 each. Prerequisite: consent of school.

Course material devoted to special topics of current interest, treatment of new developments in various areas of aerospace engineering.

A.E. 4804-14-24-34-44-54. Special Topics

4-0-4 each. Prerequisite: consent of school.

Course material devoted to special topics of current interest, treatment of new developments in various areas of aerospace engineering.

A.E. 4805-15-25-35-45-55. Special Topics

5-0-5 each. Prerequisite: consent of school.

Course material devoted to special topics of current interest, treatment of new developments in various areas of aerospace engineering.

A.E. 4900-1-2. Special Problems in Aerospace Engineering

Credit to be arranged. Prerequisite: third quarter junior or senior standing and approval of director.

Research on a problem selected in consultation with a faculty member. A brief description, endorsed by the adviser, must be approved by the school director.

A.E. 6001. Foundations of Fluid Mechanics

4-0-4. Prerequisite: consent of school.

Development of the conservation equations of a multicomponent, reacting fluid from both the continuum and molecular viewpoints. Stress tensor, heat transfer vector and diffusion velocity.

Text: *Physical Gas Dynamics*, Vincenti and Kruger.

A.E. 6010. Viscous Flow I

3-0-3. Prerequisite: consent of school.

Exact solutions of Navier-Stokes equations, Stokes flow, boundary layer equations, similarity solutions and integral methods for incompressible flow, compressible laminar boundary layer, viscous hypersonic flow.

A.E. 6011. Viscous Flow II

3-0-3. Prerequisite: A.E. 6010 or consent of school.

Transition from laminar to turbulent flow, equations of motion for turbulent flows, incompressible boundary layers, compressibility and heat

transfer, semi-empirical methods, wakes and jets.

A.E. 6020. Elements of Compressible Flow 3-0-3. Prerequisite: consent of school.

Defining equations for inviscid compressible flows, method of characteristics for unsteady one-dimensional and steady two-dimensional and axially symmetric flows, nozzle design, conical flow.

A.E. 6021. Advanced Compressible Flow Theory I 3-0-3. Prerequisite: A.E. 6020 or consent of school.

The linearized potential equation, thin airfoil theory, similarity rules, linear theory for axially symmetric and three-dimensional flows.

A.E. 6022. Advanced Compressible Flow Theory II 3-0-3. Prerequisite: A.E. 6021.

Mixed subsonic—supersonic flows, transonic similarity rule, two-dimensional and axially symmetric bodies in transonic flow, selected topics.

A.E. 6023. Hypersonic Flow Theory 3-0-3. Prerequisite: A.E. 6021 or consent of school.

Hypersonic similarity rule, hypersonic small disturbance theory, Newtonian flow theory and other approximate methods, boundary layer interaction, the blunt body problem.

A.E. 6030. Advanced Potential Flow I 3-0-3. Prerequisite: A.E. 3002.

Development of the nonlinear and linearized unsteady potential flow equations. Solutions to incompressible flow problems of airfoils and wings undergoing steady, oscillatory and arbitrary motions.

A.E. 6031. Advanced Potential Flow II 3-0-3. Prerequisite: A.E. 6030.

Formulation of aerodynamic influence coefficients, solutions to subsonic, supersonic and hypersonic flow problems of wings and bodies experiencing oscillatory and arbitrary motions.

A.E. 6040. Rarefied Gasdynamics I 3-0-3. Prerequisite: consent of school.

Mass, momentum and energy transfer in linearized rarefied gas flows, free molecular external and internal flows, statistical models for collision integral of Boltzmann equation.

A.E. 6041. Rarefied Gasdynamics II 3-0-3. Prerequisite: A.E. 6040.

Mass, momentum and energy transfer in nonlinear rarefied gas and plasma flows, statistical models for diatomic and ionized gases, discus-

sions of allied topics in ionospheric aerodynamics.

A.E. 6050. High-Temperature Gas Dynamics I 3-0-3. Prerequisite: A.E. 6260 or consent of school.

Real gas effects. Equilibrium properties and rate processes of high temperature gases. Equilibrium and frozen flows, normal and oblique shocks, nozzle flows, Prandtl-Meyer flows.

A.E. 6051. High-Temperature Gas Dynamics II 3-0-3. Prerequisite: A.E. 6050.

Acoustic equations and rate equations. Vibrational and chemical nonequilibrium flows, normal and oblique shock structures, theory of nonequilibrium characteristics, nonequilibrium acoustic waves, flow over corners.

A.E. 6100. Advanced Structural Analysis I 3-0-3. Prerequisite: A.E. 3101 or consent of

Stability of mechanical models, elastic bars and frames by kinetic and energy approaches, approximate methods for critical loads, dynamic stability and inelastic effects.

A.E. 6101. Advanced Structural Analysis II 3-0-3. Prerequisite: A.E. 6100 or consent of school.

Buckling of plates, torsional instability of thin open section columns, lateral buckling of beam beams on elastic foundation, further discussion of dynamic stability.

A.E. 6102. Advanced Structural Analysis III 3-0-3. Prerequisite: A.E. 6100, E.S.M. 6372 or consent of school.

Stability of plates, cylindrical shells, edge effects, complete spheres and shallow spherical caps, recent developments.

A.E. 6103. Advanced Structural Analysis IV 3-0-3. Prerequisite: A.E. 3102 or consent of school.

Principle of virtual work. Concepts of potential energy and complementary energy, weighted residuals, applications in approximate solutions. Discussion of Hookean material, including thermal strains.

A.E. 6104. Advanced Structural Analysis V 3-0-3. Prerequisite: A.E. 6103 or consent of school.

Introduction to finite element analysis, with emphasis on the displacement analysis of structures. Applications to static equilibrium, vibration and stability. Nonlinear formulation, solution techniques.

A.E. 6105. Aerospace Structures Laboratory 1-6-3. Prerequisite: A.E. 6104 or consent of school.

Development of practical methods for experimental mechanics, design and execution of experiments, measurement of displacement, strain, force, acceleration, temperature, design of transducers and instrument systems.

A.E. 6120. Thermal Effects in Structures I 3-0-3. Prerequisite: Math. 4582.

Analysis of heat transfer in structural elements, development and use of approximate numerical and analytical solution procedures.

A.E. 6121. Thermal Effects in Structures II 3-0-3. Prerequisite: E.S.M. 6321 or consent of school.

Analysis of thermally induced stresses in beams, plates and shells, thermally induced instability in columns and plates, reduction in torsional rigidity.

A.E. 6122. Thermal Effects in Structures III 3-0-3. Prerequisite: E.S.M. 6321 or consent of school.

Phenomenological and mechanistic interpretations of mechanical behavior of solids. Formulation and solution of problems involving elastic, plastic, linear and nonlinear viscoelastic and viscoplastic behavior.

A.E. 6130. Structural Dynamics I 3-0-3. Prerequisite: A.E. 3101, E.S.M. 4210.

Single and multiple degree-of-freedom systems, damping effects, Duhamel superposition integral. Normal modes and equations of motion, Lagrange's equations, methods of obtaining normal modes.

A.E. 6131. Structural Dynamics II 3-0-3. Prerequisite: A.E. 6130.

Vibrations of continuous elastic systems. Stodola and Rayleigh-Ritz methods. Timoshenko beam, longitudinal vibrations. Elastic and plastic waves, analysis of complex structures by modal coupling.

A.E. 6200. Advanced Aeroelasticity I 3-0-3. Prerequisite: A.E. 6130.

Static aeroelastic analyses of flight vehicles, lifting surface and panel flutter analyses with applications. Dynamic response and load studies of flight vehicles using modal techniques.

A.E. 6201. Advanced Aeroelasticity II 3-0-3. Prerequisite: A.E. 6200.

Formulation of aeroelastic analyses associated with discrete and random dynamic loads, aerodynamic and structural instabilities of fixed and rotating-wing flight vehicles.

A.E. 6202. Experimental Aeroelasticity 3-0-3. Prerequisite: A.E. 6200.

Analog computing techniques with applications, flexibility influence coefficient measurements. Vibration testing for modal identification, wind tunnel and inflight flutter tests including model scaling and construction.

A.E. 6203. Special Topics in Aeroelasticity I 3-0-3. Prerequisite: A.E. 6200.

Current topics in aeroelasticity, unsteady aerodynamics and structural dynamics are studied. The student presents both an oral and written report on two specialized current problems.

A.E. 6204. Special Topics in Aeroelasticity II 3-0-3. Prerequisite: A.E. 6200.

Continuation of A.E. 6203. Advanced problems in aeroelasticity, unsteady aerodynamics or structural dynamics.

A.E. 6250. Rocket Propulsion I 3-0-3. Prerequisite: A.E. 6260.

Flight mechanics, performance of the ideal rocket engine. Properties and performance characteristics of chemical propellants, nozzle designs and losses.

A.E. 6260. Thermodynamics of Gases 4-0-4. Prerequisite: consent of school.

Thermodynamics of reacting gases. Introductory quantum theory, statistical thermodynamics and chemical kinetics.

A.E. 6261. Combustion I 3-0-3. Prerequisite: A.E. 6260 or consent of school.

Introductory chemical kinetics, explosions, Schvab-Zeldovich formulation. Rankine-Hugoniot relations, detonations and deflagrations.

A.E. 6262. Combustion II 3-0-3. Prerequisite: A.E. 6261.

Laminar diffusion flames and droplet burning. Laminar flame propagation in premixed gases, turbulent flames, ignition quenching and flammability limits. Chemical reactions in boundary layers.

A.E. 6400. Aerodynamics of the Helicopter I 3-0-3. Prerequisite: A.E. 4400.

Forward flight performance, derivation and study of the induced velocity relations and the flow field associated with helicopter rotors.

A.E. 6401. Aerodynamics of the Helicopter II 3-0-3. Prerequisite: A.E. 6400.

Vortex-wake theories for rotors with a finite number of blades, introduction to helicopter stability and control.

A.E. 6460. Aerodynamic Noise

3-0-3. Prerequisite: A.E. 6761.

Jet, boundary layer, combustion, propeller and fan noise. Sonic boom, noise propagation from engines and attenuation techniques.

A.E. 6500. Advanced Stability and Control

3-0-3. Prerequisite: A.E. 4500.

A study of feedback controls as applied to aircraft, root locus techniques and use of airframe transfer functions are emphasized. Survey of the load alleviation problem.

A.E. 6750. System Design Methodology

2-3-3. Prerequisite: graduate standing or consent of school.

Relationship of technological systems to society is studied using economic concepts. Emphasis on the use of engineering type analysis in resolving value laden problems. Examples. Also taught as E.E. 6372, M.E. 6750.

A.E. 6751-2. Complex Systems Design

2-4-3 each. Prerequisite: graduate standing.

This two-quarter sequence permits students from all schools to meet, form an interdisciplinary team and carry out a preliminary design of a significant, complex system. Also taught as E.E. 6751-2 and M.E. 6751-2.

A.E. 6760. Engineering Acoustics I

3-0-3. Prerequisite: consent of school.

Introductory analytical methods, stochastic processes, the wave equation in a compressible fluid and problems in the radiation of sound. Also taught as E.S.M. 6760 and M.E. 6760.

A.E. 6761. Engineering Acoustics II

3-0-3. Prerequisite: A.E. 6760.

Sound reflection and refraction, scattering and diffraction, sound radiation and duct acoustics. Also taught as E.S.M. 6761 and M.E. 6761.

A.E. 6762. Engineering Acoustics III

3-0-3. Prerequisite: A.E. 6761.

Advanced duct acoustics, wave dispersion and attenuation, acoustics in moving media, geometrical acoustics, nonlinear acoustics. Also taught as E.S.M. 6762 and M.E. 6762.

A.E. 6763. Noise Reduction and Control (Industrial Applications)

3-0-3. Prerequisites: A.E. 4760 or equivalent and 6760.

Methods of noise reduction and control applied to systems in industry. Measurement of sound power, material acoustic properties, barriers, enclosures, mufflers, vibration reduction and damping methods. Also taught as E.S.M. 6763 and M.E. 6763.

A.E. 6764. Ocean Acoustics

3-0-3. Prerequisite: Geol. 4300 or consent of school. Math. 4321, 4582. A.E. 6760 recommended.

Propagation of sound waves in the oceans, stress-strain relationships, asymptotic ray theory. Propagation in shallow water and deep water. Also taught as E.S.M. 6764, Geol. 6764 and M.E. 6764.

A.E. 6791. Turbulence and Atmospheric Dynamics

3-0-3. Prerequisite: consent of school.

Introduction to turbulence, turbulent transport of momentum and heat, dynamics of turbulence, boundary-free and wall-bounded shear flows, statistical description and spectral dynamics of turbulence. Also taught as Geo.S. 6791.

A.E. 6792. Air Pollution Meteorology

3-0-3. Prerequisite: consent of school.

Fundamentals of air pollution meteorology, engineering approach to atmospheric diffusion, natural removal processes, urban and regional problems, meteorological instruments, air pollution climatology. Also taught as Geo.S. 6792.

A.E. 6794. Atmospheric Boundary Layer

3-0-3. Prerequisite: A.E. 6300 or 6301 or consent of school.

Structure and aerodynamic characteristics of atmospheric boundary layer, turbulent transport of contaminants in environment, stratified and disturbed atmospheric boundary layer, free-convection layer, current problems. Also taught as Geo.S. 6794.

A.E. 6800. Numerical Fluid Dynamics I

3-0-3. Prerequisite: A.E. 6010 or consent of school.

Finite-difference and finite-element methods for the numerical solution of fluid dynamic equations. Current methods for the numerical solution of potential flow and boundary layer problems.

A.E. 6801. Numerical Fluid Dynamics II

3-0-3. Prerequisite: A.E. 6800.

Numerical methods of solution of boundary layer equation and Navier-Stokes equations for time-dependent and steady flows. Accuracy, stability and computational efficiency.

A.E. 7000. Master's Thesis**A.E. 7600. Perturbation Methods in Engineering Analysis**

3-0-3. Prerequisite: consent of school.

Regular and singular perturbation theory, WKBJ method and the method of weighted residuals. Problems drawn from fluid mechanics and structures.

A.E. 7750. Bio-Fluid Mechanics

3-0-3. Prerequisite: A.E. 6000 or E.S.M. 6501-2 or consent of school.

A unified treatment on hemorheology, hemodynamics, pulsatile flows, microcirculation, joint lubrication, pulmonary physiology, etc., with emphasis on a quantitative approach. Also taught as E.S.M. 7750.

A.E. 7760. Magnetogasdynamics I

3-0-3. Prerequisite: A.E. 6040 or equivalent.

Fundamental concepts of plasma dynamics, magnetogasdynamic regions motion of charged particles in electromagnetic fields. Debye shielding length, Maxwell transport equations and magnetogasdynamic equations. Also taught as M.E. 7760.

A.E. 7761. Magnetogasdynamics II

3-0-3. Prerequisite: A.E. 7760.

Transport properties of ionized gases, Hall effect, ion slip, electron runaway. Equilibrium and nonequilibrium ionization, magnetoacoustic and Alfvén waves. Magnetogasdynamic shocks, magnetogasdynamic flow phenomena. Also taught as M.E. 7761.

A.E. 7762. Magnetogasdynamics III

3-0-3. Prerequisite: A.E. 7761.

Engineering applications of magnetogasdynamics. Magnetogasdynamic power generation, space propulsion, pumps and meters, available experimental data. Characteristics of magnetogasdynamic systems, geophysical and astronomical applications. Also taught as M.E. 7762.

A.E. 7763. Methods of Experimental Magnetogasdynamics

2-3-3. Prerequisite: A.E. 7762.

Laboratory plasma source and flow devices. Theories and applications of plasma diagnostic methods—spectroscopy, microwave interferometry, Langmuir probe, etc. Field trips to representative facilities. Also taught as M.E. 7763.

A.E. 7999. Preparation for Doctoral Qualifying Exams

Noncredit. Prerequisite: consent of director.

A.E. 8000. Seminar

1-0-1.

A.E. 8103-13-23-33-43-53. Special Topics

3-0-3 each. Prerequisite: consent of school.

Special topics of current interest, treatment of new developments in various areas of aerospace engineering.

A.E. 8104-14-24-34-44-54. Special Topics

4-0-4 each. Prerequisite: consent of school.

Special topics of current interest, treatment of

new developments in various areas of aerospace engineering.

A.E. 8105-15-25-35-45-55. Special Topics

5-0-5 each. Prerequisite: consent of school.

Special topics of current interest, treatment of new developments in various areas of aerospace engineering.

A.E. 8106-16-26-36-46-56. Special Topics

6-0-6 each. Prerequisite: consent of school.

Special topics of current interest, treatment of new developments in various areas of aerospace engineering.

A.E. 8500-1-2. Special Problems in Aerospace Engineering

Credit to be arranged. Prerequisite: consent of school.

A.E. 8503-4-5. Special Problems in Aerospace Engineering

Credit to be arranged.

A.E. 8999. Preparation for Doctoral Dissertation

Noncredit. Prerequisite: consent of director.

A.E. 9000. Doctoral Thesis

AIR FORCE AEROSPACE STUDIES

A.S. 1610. Introduction to Today's Air Force
1-1-1.

United States Air Force doctrine, mission and organization with an introduction to strategy.

A.S. 1620. Air Force Operational Activities
1-1-1.

United States Air Force strategic and general purpose forces, emphasis on their mission, employment and weapon systems.

A.S. 1630. Air Force Support Activities
1-1-1.

A survey of support commands and operating agencies of the United States Air Force.

A.S. 2610. Air Power, the Early Years
1-1-1.

A study of the principles of manned flight and doctrine of air power from the seventeenth century through the 1930s.

A.S. 2620. Air Power, W.W. II to Korea
1-1-1.

An examination of the development of air power doctrines in W.W. II, the Berlin airlift and the Korean War.

A.S. 2630. Air Power, the Later Years
1-1-1.

An examination of the role of air power in contemporary times including the Middle East, Cuba and Southeast Asia.

A.S. 3410. Air Force Management I
3-1-3.

Introduction to Air Force management, individual and group behavior and communicative skills.

A.S. 3420. Air Force Leadership
3-1-3.

Analysis of leadership dynamics and principles as they apply to command and management.

A.S. 3430. Air Force Management II
3-1-3.

Fundamentals, functions and techniques of management. Stresses Air Force approach to management.

A.S. 4310. Civil-Military Relations
3-1-3.

A study of the environment of current and historical civil military relations and the sociological aspects of the military profession.

A.S. 4320. U.S. Defense Policy
3-1-3.

An organizational behavior investigation of the formulation and implementation of United States defense policy.

A.S. 4330. Military Justice
3-1-3.

Functions of the military justice system. Stresses differences and similarities between civil and military law.

ARCHITECTURE

Architecture

Arch. 1001-2-3. Design Fundamentals
1-12-5 each.

Introductory studies in visual and structural expression emphasizing the processes of problem identification, design method and communication.

Arch. 1201-2-3. History of Architecture I, II, III
3-0-3 each.

A study of man's architectural heritage from the beginning of recorded history to the present day. Open to all freshmen.

Arch. 2001-2-3. Architectural Design
1-12-5 each. Prerequisite: Arch. 1003. Corequisite: Arch. 2301-2-3 respectively.

Design of simple buildings emphasizing technical subjects in corequisite courses.

Arch. 2301-2-3. Building Anatomy I, II, III
3-0-3 each.

Introduction to building frames, components and construction techniques, requirements and design of climate control systems, sound and lighting control.

Arch. 2361-2. Color Theory
1-3-2 each.

Lecture and laboratory experiments on the properties of color and its use in design.

Arch. 3001-2-3. Architectural Design
1-12-5 each. Prerequisite: Arch. 2003, 2303. Corequisite: Arch. 3401-21-41, respectively.

Site planning, community and urban design. Design of complex facilities, in association with corequisite courses.

Arch. 3201. History of Ancient Architecture
3-0-3. Prerequisite: Arch. 1201-2-3 or consent of the college.

Historical survey of the architecture of antiquity from prehistoric times through the second century A.D. Emphasizes the architectural traditions of classical antiquity.

Arch. 3202. History of Medieval Architecture
3-0-3. Prerequisite: Arch. 1201-2-3 or consent of the college.

Historical survey of architecture in Medieval Europe including the Early Christian, Byzantine, Dark Ages, Romanesque and Gothic eras.

Arch. 3203. History of Renaissance and Mannerist Architecture
3-0-3. Prerequisite: Arch. 1201-2-3 or consent of the college.

Historical survey of European architecture in the Renaissance and Mannerist periods.

Arch. 3204. History of Baroque and Rococo Architecture
3-0-3. Prerequisite: Arch. 1201-2-3 or consent of the college.

Historical survey of European architecture during the seventeenth and eighteenth centuries.

Arch. 3205. The Architect and Society
3-0-3. Prerequisite: Arch. 1201-2-3 or consent of the college.

The role of the architect in society from the Classical Greek period to the twentieth century.

Arch. 3321-2-3. Structures and Materials I, II, III
4-3-5 each. Prerequisite for Arch. 3321: Arch. 2301, ESM 3702; prerequisite for Arch. 3322 and 3323: Arch. 3321.

Wood, masonry, light-steel frames, steel, reinforced-concrete, integration of steel and concrete, indeterminate structures. Design, application, specification and testing of components.

Arch. 3401-21-41. Urban Planning, Facilities Planning, Building Economics
3-0-3 each.

Survey and historic background of urban planning in the United States; criteria for design and evaluation of buildings; economics of building development, construction and operation.

Arch. 3780. Introduction to Urban Engineering
3-0-3. Prerequisite: junior standing in engineering or architecture or consent of instructor.

Survey of the current status of scientific and technical contributions to urban socioeconomic problems and opportunities for increased participation by engineering architectural and related disciplines.

Arch. 3811-2. Visual Communications Studio
0-3-1 each.

Introductory studio work in drawing and painting, sculpture and three-dimensional concepts.

Arch. 3815-6. Visual Communications Studio
0-6-2 each.

Introductory studio work in drawing and painting, sculpture and three-dimensional concepts.

Arch. 3911-2-3-4. Visual Communication Studios
0-3-1 to 0-15-5.

Introductory studio work in: (1) drawing and painting, (2) sculpture and three-dimensional concepts, (3) photography, (4) graphic design and rendering.

Arch. 4001. Architectural Design
1-12-5. Prerequisite: Arch. 3003.

Architectural design synthesizing material presented in previous years.

Arch. 4002-3. Architectural Design
1-12-5 each. Prerequisite: Arch. 4001.

Terminal project. Selection of a facility for design by the individual student, with approval by the faculty. Research and programming for terminal project. Schematic and final design and preparation of design documents. Undergraduate exit exam project.

Arch. 4204. History of Architecture in England I
3-0-3. Prerequisite: Arch. 1201-2-3 or consent of the college.

Historical survey of architecture in England from Roman times to 1715. Focus is on cathedrals and on domestic architecture from castles and fortified manor houses to Tudor, Elizabethan, Jacobean and Baroque country houses.

drals and on domestic architecture from castles and fortified manor houses to Tudor, Elizabethan, Jacobean and Baroque country houses.

Arch. 4205. History of Architecture in England II
3-0-3. Prerequisite: Arch. 1201-2-3 or consent of the college.

Historical survey of architecture in England from Wren to the present, concentrating on the eighteenth and nineteenth centuries.

Arch. 4206. History of Architecture in the U.S.
3-0-3. Prerequisite: Arch. 1201-2-3 or consent of the college.

Historical survey of architecture in America from colonial times to the present.

Arch. 4207. History of Modern Architecture I: Nineteenth Century
3-0-3. Prerequisite: Arch. 1201-2-3 or consent of the college.

Historical survey of architecture in the nineteenth century focusing upon currents of romanticism, classicism, eclecticism, vernacular styles and the advances in engineering and building technology.

Arch. 4208. History of Modern Architecture II: 1890-1950
3-0-3. Prerequisite: Arch. 1201-2-3 or consent of the college.

Historical survey of architecture during the early modern movement. Focuses upon the old masters. (Gropius, Wright, Le Corbusier and Mies van der Rohe) and introduces such modern movements as Art Nouveau, DiStijl, International Style and Art Deco.

Arch. 4209. History of Modern Architecture III: 1945-present
3-0-3. Prerequisite: Arch. 1201-2-3 or consent of college.

Historical survey of architecture since World War II, focusing upon the influence of the old masters of modern architecture upon architects active after 1945. Introduces such trends as the Miesian Aesthetic, New Formalism and New Brutalism and Post-Modernism.

Arch. 4247-8-9. History of Art I, II, III
3-0-3 each.

A survey in the history of artistic manifestations from primitive times to our own day. First quarter of sequence: prehistoric through Roman; second quarter: Early Christian through Baroque; third quarter: nineteenth and twentieth centuries.

Arch. 4301. Building Materials I
3-0-3. Prerequisite: Arch. 3323.

Relevant physical properties, manufacturing

processes, utilization within the building industry, and methods for stipulating quality control of masonry, concrete and metallic building materials.

Arch. 4302. Building Materials II

3-0-3. Prerequisite: Arch. 3323, 4301.

Recent developments in building technology. Resins and elastomers, properties and utilization. Composites: studies of innovative use of new building materials.

Arch. 4321. Structural Integration

3-3-4. Prerequisite: consent of college.

Study of structural systems for buildings, and of methods used in their design and analysis.

Arch. 4751-2. Psychology of Environmental Design

3-3-4 each. Prerequisite: consent of college.

Course listing and description found under Psy. 4751-2.

Arch. 4771-2. Urban Systems Design

2-3-3. Prerequisite: Arch. 3780 or consent of college.

Analysis of an unstructured urban problem situation by multidisciplinary group. Groups identify, structure and analyze a specific local off-campus urban problem and propose a solution to that problem.

Arch. 4775. Sociotechnical Problems in Energy Engineering

3-0-3. Prerequisite: senior standing or consent of the college.

The examination of problems and opportunities in the area of energy from social and technical viewpoints. The analysis is presented to develop a multidisciplinary perspective.

Arch. 4776. Impact of Energy Problems

3-0-3. Prerequisite: senior standing or consent of the college.

Provides a working knowledge of the interaction and impact of energy on the individual and society.

Arch. 4777. Energy Flow in a Systems Context

3-0-3. Prerequisite: senior standing or consent of the college.

The study of energy and energy flow in a systems context.

Arch. 4778. Energy Lab

0-9-3. Prerequisite: senior standing or consent of the college.

Individual and group projects dealing with development and application of energy systems.

Arch. 4811-2. Visual Communications Studio
0-3-1 each.

Intermediate studio work in drawing and painting, sculpture and three-dimensional concepts.

Arch. 4815-6. Visual Communications Studio
0-6-2 each.

Intermediate studio work in drawing and painting, sculpture and three-dimensional concepts.

Arch. 4821-2-3. Special Topics in History and Theory

3-0-3 each. Prerequisite: consent of college.

Research in advanced areas of history and theory of architecture.

Arch. 4851-2-3. Special Topics

3-0-3 each.

Arch. 4911-2-3-4. Visual Communications Studios

0-3-1 to 0-15-5. Prerequisite: Arch. 3911-2-3-4.

Intermediate studio work in: (1) drawing and painting, (2) sculpture and three-dimensional concepts, (3) photography, (4) graphic design and rendering.

Arch. 4915-6-7-8. Visual Communications Studios

Credit to be arranged. Prerequisite: consent of college.

Self-directed studies in visual communications arts.

Arch. 4941-2-3. Special Problems

Credit to be arranged.

Arch. 4951-2-3-4. Special Problems

Credit to be arranged.

Arch. 4994-5. Special Problems

Credit to be arranged.

Arch. 6001-2-3. Architectural Design

3-18-9 each. Prerequisite: graduate standing.

Problems in design applied to related theory in urban design, architecture and behavioral studies in architecture.

Arch. 6004-5-6. Architectural Design

3-18-9 each. Prerequisite: graduate standing.

Design of complex building facilities and their environments.

Arch. 6302. Building Performance I

3-0-3. Prerequisite: graduate standing.

Introduction to methods used to evaluate the performance of buildings, building systems and components. Criteria and basis to formulate performance specifications.

Arch. 6322. Prestressed Concrete Structures in Architecture

3-0-3.

Structural characteristics of prestressed concrete structures, manufacturing techniques, application to architectural problems, economic factors, principles of analysis and design.

Arch. 6351. Advanced Architectural Acoustics

3-0-3. Prerequisite: Arch. 2303 or equivalent.

Design requirements for noise control and acceptable room acoustics. Practical design problems, materials selection and calculation of sound propagation parameters.

Arch. 6401. Landscape Resource Analysis.

3-0-3. Prerequisite: graduate standing.

Analysis and design methods for solving large scale or complex site development problems in both the public and private sectors.

Arch 6402. Introduction to the Preservation and Conservation of Cultural Resources.

3-0-3. Prerequisite: graduate standing.

Review of preservation and conservation as social attitudes, as public policy concerns and as discrete areas of knowledge. Emphasis will be given to historic preservation as a specialty within the general context of the built environment.

Arch. 6421. Industrialized Housing

3-0-3.

An examination of the problems and proposed solutions to the design, manufacture, marketing and utilization of industrialized building systems to provide housing.

Arch. 6431. Architectural Settings for Health Related Activities

3-1-3. Prerequisite: consent of instructor.

The planning and design of architectural settings for health related activities (excluding hospitals). Analysis of user needs. Programmatic, environmental and construction requirements.

Arch. 6432. Medical Center Process and Planning

3-1-3. Prerequisite: consent of instructor.

The programming and planning of medical centers, location analysis and site planning. Identification and analysis of major functional subsystems. Investigation of activity linkages. Space allocation programming.

Arch. 6433. Activity Settings in Medical Centers: Planning and Design

3-1-3. Prerequisite: consent of instructor.

The architectural settings for departmental ac-

tivities in the contemporary medical center. Detailed analysis of user needs and the programmatic design and construction requirements.

Arch. 6441. Housing Economics

3-0-3. Prerequisite: graduate standing.

Economics of the housing delivery process in the private sector. Planning, developmental marketing and management of housing.

Arch. 6442. Construction Cost and Valuation.

3-0-3. Prerequisite: graduate standing.

Cost and valuation approaches to building construction, project development and design from an economic valuation viewpoint. Income producing properties are studied in depth.

Arch. 6443. Economics of Building Development

3-6-9. Prerequisite: Arch 6442.

Case studies of economic success of student designs and existing projects. Income statements are constructed, pro formas prepared and rates of return determined.

Arch. 6444. Building Life Cycle Costing

2-4-3. Prerequisites: Arch. 3441; graduate standing.

This course explores the concepts and application of life cycle costing as a basis for architectural design evaluation. The effects of capital investment and annual costs including energy consumption are explored.

Arch. 6451. Professional Practice of Architecture

3-0-3. Prerequisite: graduate standing.

Principles of architectural office organization and project management, the legal framework of architectural practice and contracts, and the techniques of contract administration.

Arch. 6751-2. Complex Systems Design

2-4-3 each. Prerequisite: graduate standing.

Students from various disciplines analyze and design a major complex urban system.

Arch. 6781-2. Projects in Urban Systems Design

0-9-3 each.

Analysis of an unstructured urban problem situation by a multidisciplinary group. Groups identify, structure and analyze a specific local off-campus urban problem and propose a solution for that problem.

Arch. 7000. Thesis

Arch. 7004-5-6. Architectural Design
2-21-9 each. Prerequisite: Arch. 6003 or equivalent.

Design of complex building facilities and their environments.

Arch. 7221. Origin and Evolution of Cities
3-0-3.

Morphological analysis of urban physical settlement patterns. Ecological, social, economic and cultural characteristics as determinants of urban form and structure from prehistory to present.

Arch. 7222. Theories and Principles of Urban Design
3-0-3.

Theories and principles of design revealed through pathological analysis of cities, proposed designs for ideal cities, relevance of psychology and aesthetics as base for urban design.

Arch. 7402. Urban Design Research
1-6-3.

Independent research for means to improve urban environment. Detailed statement of problem, hypothesis, research methodology and products to be submitted must be approved by staff before enrollment.

Arch. 7804-5-6. Problems in Urban Design I, II, III
3-18-9 each. Prerequisite: graduate standing.

Wide range of contemporary urban problems, considerations and judgments at regional, metropolitan/city and subcity scales. Survey and analysis of new and built environments. Formulation and design of comprehensive land use systems, transportation systems, education, health and open space/recreation systems, and urban services systems. Current and emerging means of plan implementation.

Arch. 8143-53-63-73-83-93. Special Topics
3-0-3 each.

Arch. 8151-2-4-5-6. Special Topics
1-0-1 through 6-0-6, respectively.

Arch. 8521-2-3. Special Problems in Architectural History
Credit to be arranged.
Individual study of selected periods, architects, schools or building types.

Arch. 8531-2. Special Problems
Credit to be arranged.
Only for students majoring in structures.

Arch. 8541-2-3. Special Studies in Urban Problems

Credit to be arranged.

Independent study of advocacy planning as a force for improving the quality of the urban environment. Admission to courses permitted upon approval by instructor of applicant's proposed study program.

Arch. 8550-1-2-3-4-5-6. Special Problems
Credit to be arranged.

Building Construction

B.C. 1851. Building Construction Seminar
0-3-1.

Introduction to the construction industry. Sources, properties and uses of construction materials.

B.C. 2001. Design of Building Systems I
1-12-5. Prerequisite: Math. 1309, B.C. 1851. Corequisite: Arch. 2301, Phys. 2111.

Study and analysis of job planning required, work methods, materials, systems and equipment employed on light construction projects which include residential and small commercial buildings.

B.C. 2002. Design of Building Systems II
1-12-5. Prerequisite: B.C. 2001. Corequisite: Arch. 2303.

Continuation of B.C. 2001 with emphasis on medium sized commercial and industrial projects.

B.C. 2003. Design of Building Systems III
1-12-5. Prerequisite: B.C. 2002. Corequisite: Arch. 2303.

Classification of work and quantity survey techniques. Analysis and determination of cost of construction operations including preparation of bid proposals.

B.C. 3301. Construction Practice I
3-0-3. Prerequisite: B.C. 2003.

Principles, methods, organizations and problems related to construction management.

B.C. 3302. Construction Practice II
3-0-3. Prerequisite: B.C. 3301, Mgt. 3260.

Management contracts, bonds, insurance, documents and legal aspects of construction management.

B.C. 3303. Construction Practice III
3-0-3. Prerequisite: B.C. 3302, Mgt. 3700.

Financial consideration and cash flow requirements for construction projects and organizations.

B.C. 3441. Building Production
3-0-3. Prerequisite: B.C. 2003.

Methods analysis and human factors in construction project management. Processes by which building facilities are produced and delivered.

B.C. 4301. Construction Systems
3-0-3.

Review and examination of major component building systems in use today. Discussion of anticipated future requirements for systems and potential impacts on the construction process.

B.C. 4441. Land Development
3-0-3.

Fundamentals underlying the economics and political determinants of land use, ecological considerations and the techniques for implementing the development of land.

B.C. 4442. Value Engineering in Construction
3-0-3.

Analysis of material, equipment, facilities, procedures and supplies to achieve lowest possible cost consistent with performance requirements to attain optimum quality in building.

B.C. 4443. Industrial and Construction Safety
3-0-3.

The 1970 Occupational Safety and Health Act as it applies to the building contractor to provide safe working conditions and to the designer to provide safety in buildings.

B.C. 4444. Real Estate Investment
3-0-3.

Fundamentals underlying the economic structure of physical development. A study of the matrix of development processes and investment decisions.

B.C. 4446. Construction Management
3-0-3.

Management of construction processes including the pre-design, design and construction phases. Services and methods used by architects, contractors and independent consultants performing construction management.

B.C. 4951-2-3. Special Problems in Construction

Credit to be arranged. Prerequisite: senior standing and special permission.

Special problems in construction methods, schedules or management for students in advanced architectural design or construction projects. Research in innovative methods, processes, systems of construction.

City Planning

C.P. 1100. Introduction to City Planning
3-0-3. Fall quarter.

An orientation to urban and regional planning including organization, functions, techniques and methods of implementation.

C.P. 6000. Introduction to and Theory of Planning
3-0-3.

Introduction to the profession of planning; examination of theories of planning; analyses of futurist thought, comprehensiveness, citizen participation, professionalism, the public interest, and planning roles and practices.

C.P. 6010. Land Use Planning
3-0-3.

Factors determining land use, location and interrelationships of various land uses, land use studies and plan preparation, implementation of land use policies and plans.

C.P. 6020. Planning Legislation and Regulation
3-0-3.

Theory and use of eminent domain, taxing and police powers, enabling acts, charters, official maps, codes, restrictive covenants, controlled highway access legislation.

C.P. 6030. Planning Legislation and Regulation
3-0-3.

An intensive study of zoning—its history, principles, uses and limitations through review of significant court cases and subdivision regulations.

C.P. 6050. Housing and Urban Renewal
3-0-3.

Urban renewal problems, programs and techniques including legislation, identification of renewal areas, planning, administration, relocation, financing and real estate problems.

C.P. 6060. State and Regional Planning
3-0-3.

Basic concepts and theories of state and regional planning examined in detail. The history, background, organization and techniques and methods are studied.

C.P. 6070. Public Works Planning I
3-0-3.

Planned change in context of public works planning and development, plan implementation, population analysis, public participation, conflict value assessment and information transfer.

C.P. 6080. Public Works Planning II
3-0-3.

The institutional setting in which public works planning takes place, elements of the planning process and techniques for the assessment of economic, social and environmental impact.

C.P. 6090. Fiscal Aspects of Urban Planning
3-0-3.

Survey of public sector financial planning and management techniques, emphasis on comprehensive planning inputs to public financial policy and operations.

C.P. 6100. Problems in City Planning
2-12-6.

Development of a new town, organization of its government, public and private programs to meet citizen needs, design of new town, preparation and evaluation of plans for specific sites.

C.P. 6110. Problems in City Planning
2-12-6.

Study of existing urban area, preparation of land use and thoroughfare plans including traffic volume estimates, fringe area annexation study, neighborhood conservation plan and program.

C.P. 6120. Problems in City Planning
2-12-6.

An in-depth study of a class basis of a specific urban or regional planning problem prepared for a client agency or citizens organization.

C.P. 6140. Environmental Aspects of City and Regional Planning I
3-0-3.

Identification and quantitative analysis of air, water, noise, spatial pollution and its influence on urban development, health and well-being. Solutions, environmental controls and management programs evaluated.

C.P. 6150. Environmental Aspects of City and Regional Planning II
3-0-3.

Field analysis of noise, air, water and spatial pollution. Students identify, evaluate and apply city planning solutions to environmental problems.

C.P. 6160. Environmental Noise Management
3-0-3.

Management and administration of environmental or community generated noise, analysis of noise impact, noise management, instrumentation, rating methods. Evaluation of laws and management programs.

C.P. 6170. Economics of Environmental Quality
3-0-3.

Topics included are the causes of market failure to provide a high quality environment, amenity resources and extra-market values.

C.P. 6210. Community Facilities Planning
3-0-3. Prerequisite: senior or graduate standing.

Basic information for architects and city planners on engineering aspects of flood control, water supply, sewage, waste collection and disposal systems, parks and open space, and public buildings.

C.P. 6260. Economics of Urban Development
3-0-3.

Economic function of urban communities, location of cities, market analysis and economic feasibility studies of retail stores, offices, hotels, housing and industrial developments and new communities.

C.P. 6270. Economic Analysis of Urban Areas
3-0-3.

An examination of methods and techniques for analyzing the economic base of urban communities, special emphasis on problems of handling population, employment and income data.

C.P. 6280. State and Local Finance
3-0-3.

Extension of C.P. 6090 with emphasis on program design, analysis, operation, evaluation, expenditure and revenue estimates, capital and operating budgets.

C.P. 6290. Economics of Urban Problems
3-0-3.

Seminar on economic and planning aspects of contemporary urban problems, emphasis on student research in particular areas of interest.

C.P. 6350. Introduction to Scientific Methods in Urban and Regional Planning
2-6-4.

Basic concepts of scientific method relevant and applicable to planning practice and theory.

C.P. 6360. Intermediate Scientific Methods in Urban and Regional Planning
2-6-4. Prerequisite: C.P. 6350 or consent of department.

A continuation of 6350, this course covers the intermediate level of modeling and other scientific methods that are relevant and applicable to city planning practice and theory.

C.P. 6370. Systemic Planning Methods in Urban and Regional Planning
2-6-4. Prerequisite: C.P. 6360 or consent of department.

A continuation of C.P. 6360, this course examines the philosophical and intellectual content of the systems approach to city planning.

C.P. 6753. Economic Aspects of Urban and Regional Planning I
3-0-3. Prerequisite: senior or graduate standing.

Introduction to cash-flow and discounting techniques. Micro-economics in project formulation and evaluation. Applications from welfare economics, project analysis, cost allocation.

C.P. 6754. Economic Aspects of Urban and Regional Planning II
3-0-3. Prerequisite: C.P. 6753.

Principles of resource allocation, benefit-cost analysis, urban and regional project formulation, justification, and application of computer simulation techniques to economic and resource allocation.

C.P. 7000. Master's Thesis
Credit to be arranged.

A research problem in city planning, selected by the student in consultation with the graduate staff. Requires one full quarter of work as a minimum with technical direction available from the graduate staff.

C.P. 8010-20-30-40-50. Seminar.
1-0-0.

A student-faculty discussion seminar devoted to planning topics in the daily news and the topics of special interest to the group. Visiting lecturers.

Industrial Design

I.D. 1261-2-3. History of Design
3-0-3 each.

A history of design, technology and innovation, with emphasis on their influence in historic cultures. Open to all students.

I.D. 2001-2-3. Industrial Design
1-12-5 each. Corequisites: I.D. 2301-2-3.

Elements of industrial design, stress on design procedures and problem solving.

I.D. 2301-2-3. Materials and Process Design
1-3-2 each.

Use of materials and processes designers use to communicate their ideas. Graphic techniques. Use of hand and power tools with wood, metals and plastics. Modelmaking techniques. Use of working drawings.

I.D. 3001-2-3. Industrial Design
1-12-5 each. Prerequisite: I.D. 2003. Co-requisites: I.D. 3301-2-3.

Lettering, typography and package design, as well as industrial design problems.

I.D. 3301-2-3. Materials and Process Design
1-3-2 each.

Production methods and their relation to design. Includes the study of major mass production techniques involved in manufacturing products and packaging through use of lectures, research and field trips to production facilities.

I.D. 4001-2-3. Industrial Design
1-18-8 each. Prerequisite: I.D. 3003.

Advanced industrial design problems, accentuating individual work in special areas of concentration.

BIOLOGY

Biol. 1001. Orientation to Biology
1-0-1.

Orientation to the biology program at Georgia Tech. The nature of biology, contemporary research in biology and career opportunities.

Biol. 1710-1-2. Introduction to Biology I, II, III
3-3-4 each.

For students interested in one year of laboratory science. Principles of genetics, physiology, taxonomy and evolution in plants and animals are discussed. Noncredit for biology majors.

Biol. 1720. Biological Principles for Engineers
4-3-5.

An introduction to biology with an emphasis on ecology and the interactions of human technology and biological systems. The implication of biology to individuals and to human technological societies will be stressed.

Text: at the level of Clark, *Contemporary Biology*, 2nd ed.

Biol. 2212, 2210-11. Principles of Biology
4-3-5 each. Prerequisite: Chem. 1112 or 1102 and consent of school. It is recommended but not required that the courses be taken in the order listed.

An intensive introduction to the cell integrated into the physiology, genetics, development, anatomy and behavior of the intact organism and the ecology and evolution of populations.

Text: at the level of Villee-Dethier, *Biological Principles and Processes*.

Biol. 3310. Introductory Microbiology I
3-6-5. Prerequisite: Biol. 2211, Chem. 3312 or consent of school.

Basic biology of bacteria, fungi, algae, proto-

zoa and viruses, with particular emphasis on bacteriology.

Biol. 3311. Introductory Microbiology II
3-6-5. Prerequisite: Biol. 3310 or consent of school.

Classification and biology of bacteria and their role in soil, water, foods and air.

Text: at the level of Frobisher, et al, *Fundamentals of Microbiology*.

Biol. 3330. Cell Physiology
4-3-5. Prerequisite: Biol. 2211 or equivalent.

Chemical, physical and biological properties of cells. Biological macromolecules, their transformations, metabolism and enzymes. Photosynthesis, protein synthesis and ionic and molecular transport in cells.

Text: at the level of Giese, *Cell Physiology*.

Biol. 3332. Biostatistics
4-3-5. Prerequisite: Math. 1308.

An introduction to statistical methods and their use in the preparation and interpretation of biological experiments.

Text: at the level of Walpole and Myers, *Probability and Statistics for Engineers and Scientists*.

Biol. 3334. Genetics
3-3-4. Prerequisite: Biol. 2210 or consent of school.

An introduction to the principles of heredity. It is recommended that Biol. 3332 be taken concurrently with Genetics if it has not been completed on schedule.

Biol. 3335. General Ecology
3-0-3. Prerequisite: either Biol. 1712 or 2212 or consent of school.

Introduction to the concepts of ecology, designed for biology majors but appropriate for interested nonmajors. Emphasizes structure and function of natural populations, communities and ecosystems.

Text: at the level of Odum, *Fundamentals of Ecology*, third edition.

Biol. 3336. General Ecology Laboratory
0-3-1. Prerequisite: Biol. 3332 or consent of school; may be taken concurrently with or following Biol. 3335.

Designed to be taken with Biol. 3335. Important aspects of ecological theory, analytical techniques and physical and chemical methods useful in ecological studies.

Text: at the level of Cox, *Laboratory Manual of General Ecology*.

Biol. 3343. Developmental Vertebrate Biology
2-6-4. Prerequisite: Biol. 2212 or equivalent.

Survey of the anatomy, embryology and phy-

logeny of vertebrate organ systems. Laboratory work involves dissection of adult organism and study of embryological slides.

Biol. 3350. Invertebrate Zoology
3-3-4. Prerequisite: Biol. 2212 or equivalent.

Phylogeny, functional morphology and adaptations of invertebrates, emphasizing broad evolutionary patterns. Dissection, gross examination and field observation of major invertebrate phyla.

Text: at the level of Barnes, *Invertebrate Zoology*.

Biol. 3351. Field Invertebrate Zoology
0-3-1. Prerequisite: Biol. 2212 or equivalent and concurrent enrollment in Biol. 3350.

Field investigations of the biology of invertebrates, including trips to the Atlantic and Gulf coasts.

Biol. 3352. Marine Invertebrate Zoology
3-6-5. Prerequisite: basic courses in general biology or general zoology or consent of school.

Morphology, distribution and systematics of marine invertebrates, with emphasis on collection and study of living organisms. Offered summer term at the Marine Science Center, Skidaway Island, Georgia.

Text: at the level of Gosner, *Guide to the Identification of Intertidal Invertebrates*.

Biol. 3360. Human Genetics
3-0-3. Prerequisite: introductory biology or consent of school.

The major concepts and problems of human genetics, designed to lead to a better understanding of how the genetic and environmental components interact to produce the human organism.

Text: at the level of Rothwell, *Human Genetics*.

Biol. 3370. Evolutionary Biology
3-0-3. Prerequisite: Biol. 3334 or consent of school.

An introduction to the evolution of living organisms, including the history of evolutionary thought, the history of life from biochemical origin through the paleontological record, with emphasis on genetic mechanisms and the interaction of genotype and environment.

Text: at the level of Futuyma, *Evolutionary Biology*.

Biol. 3711. Anatomy and Physiology
3-0-3. Prerequisite: junior standing or consent of school.

Study of human anatomy and fundamental physiological mechanisms. Designed for the advanced student in fields interdisciplinary with the life sciences. Noncredit for biology majors.

Text: at the level of Grollman, *The Human Body*.

Biol. 3801-2-3-4-5. Special Topics
1-0-1 to 5-0-5 respectively.
These courses enable the School of Biology to provide offerings dealing with areas of particular current interest in biological science.

Biol. 4405. General Virology
3-0-3. Prerequisite: Biol. 3310 or consent of school.

An integrated view of virology, bringing unity to the diversity of bacterial, mammalian, insect and plant viruses, with special emphasis on biochemical characterization of viruses and their reproduction.

Text: at the level of Luria, Darnell, Baltimore and Campbell, *General Virology*, 3rd Ed.

Biol. 4406. Medical Bacteriology
3-6-5. Prerequisite: Biol. 3310 or consent of school.

Advanced study of bacteria of significance in human disease and of immunity.

Text: at the level of Burrows, *Textbook of Microbiology* and Joklik and Smith, *Microbiology*.

Biol. 4408. Microbial Genetics
3-6-5. Prerequisite: Biol. 3310 or consent of school.

Microbial genetics, with special emphasis on the integration of genetic studies with biochemical and physical analysis of synthesis, structure and function of nucleic acids and proteins.

Text: at the level of Hayes, *The Genetics of Bacteria and Their Viruses* and selected references.

Biol. 4409. Microbial Physiology
3-6-5. Prerequisite: Biol. 3310, Chem. 3511 or consent of school.

Discussions and laboratory investigations on the physiology of growth and metabolic activities of microorganisms.

Text: at the level of Burrows, *Textbook of Microbiology*, XX edition and selected references.

Biol. 4410. Microbial Ecology
3-0-3. Prerequisite: Biol. 4406 or 4409 or consent of school.

Advanced discussions on microorganisms occupying key roles in recycling processes, microbial ecosystems and microbial evolution.

Text: at the level of Alexander, *Microbial Ecology* and selected references.

Biol. 4411. Industrial Microbiology
3-0-3. Prerequisite: Biol. 3310.

The biochemistry, genetics and technological

applications of microorganisms used in commercial processes.

Biol. 4412. Introductory Aerobiology
3-0-3. Prerequisites: Biol. 3310 or consent of school.

Physical and biological factors involved in the dissemination, survival and transport of living microorganisms by the aerial route.

Biol. 4413. Air and Water Pollution
3-0-3.

An introduction to environmental, legal, social and economic problems resulting from air and water pollution and from current pollution abatement practices. Emphasis on concerns facing engineers and biologists working in industry.

Text: at the level of Hodges, *Environmental Pollution*, 2nd Ed., and selected references.

Biol. 4415. Introductory Radiation Biology
3-3-4. Prerequisite: consent of school.

A general survey of biological systems and their responses to various kinds of radiations.

Text: at the level of Casarett, *Radiation Biology*.

Biol. 4416. Industrial Hygiene
3-0-3.

A survey of chemical, physiological, and biological hazards in the occupational environment to include: adverse effects on the body, methods of evaluation, general control measures, and governmental regulations.

Text: at the level of Olshifski and McElroy, *Fundamentals of Industrial Hygiene*, 2nd Ed., and selected references.

Biol. 4420. Limnology
3-6-5. Prerequisite: Biol. 3335 or consent of school.

Physics, chemistry and ecology of fresh water. Aquatic communities and ecosystems. Physical, chemical and biological investigations of lakes and streams, including several field trips.

Text: at the level of Reid, *Ecology of Inland Waters and Estuaries*.

Biol. 4423. Population Biology
3-0-3. Prerequisite: Biol. 2212 or consent of school.

Population ecology: dynamics and evolutionary mechanisms including modes of selection and environmental modification of genetic systems.

Text: at the level of Wilson and Bossert, *A Primer of Population Biology*.

Biol. 4425. Marine Population Biology
2-6-4. Prerequisite: introductory courses in ecol-

ogy, genetics, calculus and biostatistics, or consent of school.

An intensive field experience in theoretical population biology and its relationship to natural marine populations, including sampling techniques, data interpretation and literature review. To be taught at Skidaway Institute of Oceanography.

Text: at the level of Wilson and Bossert, *A Primer of Population Biology* and Ford and Hazen, *Readings in Aquatic Ecology*.

Biol. 4426. Estuarine Ecology

3-6-5. Prerequisite: basic courses in biology, physics, chemistry, mathematics.

A multidisciplinary field-oriented course, concerned with the geology, physics, chemistry and biology of estuaries, and the dynamics of the estuarine ecosystem. To be offered at the Marine Science Center, Skidaway Island, Georgia.

Text: at the level of McConnaughey, *Marine Biology*.

Biol. 4427. Ichthyology

3-6-5. Prerequisite: one year of general biology or general zoology and junior standing or consent of school.

Taxonomy, distribution, ecology and evolution of fishes with special reference to the marine and freshwater fishes of eastern North America. To be offered during summer term at the Marine Science Center, Skidaway Island, Savannah, Georgia.

Biol. 4432. Cytology

3-3-4. Prerequisite: Biol. 3330 or consent of school.

Modern aspects of the morphologic, functional and cytochemical organization of the cell. Preparative techniques and principles for observations in light, phase and electron microscopy.

Biol. 4435-6. Applied Biology

3-0-3 each. Prerequisite: consent of school.
Selected topics in modern biology.

Biol. 4443. General Animal Physiology I

4-3-5. Prerequisite: Biol. 3330, Chem. 3312 or consent of school.

Vertebrate systems physiology to include: muscles, nerves, circulation, respiration and body fluids.

Biol. 4444. General Animal Physiology II

3-6-5. Prerequisite: Biol. 3330, Chem. 3312 or consent of school.

Continuation of Biol. 4443, to include the following: renal systems, special senses, digestion, absorption, reproduction and the endocrine system. It is recommended but not mandatory that Biol. 4443 be taken prior to Biol. 4444.

Biol. 4445. Plant Physiology

3-6-5. Prerequisite: Biol. 3330, Chem. 3312 or consent of school.

Chemical transformations in photosynthesis, photophysiology and water relationships, organic nutrition and effect of hormones on growth and development in plants.

Biol. 4450. Seminar

2-0-2. Normally taken by seniors.

Student and staff presentations of reports on laboratory or literature searches.

Biol. 4461. Cytogenetics

3-6-5. Prerequisite: Biol. 3334, 4432.

A correlated study of genetics and cytology primarily concerned with the chromosomal basis of genetics. Laboratory experience in methodology of chromosome study including humans.

Texts: at the level of Brown, *Textbook of Cytogenetics* and Burnam, *Discussions in Cytogenetics*.

Biol. 4464. Developmental Genetics

3-0-3. Prerequisite: Biol. 3334 or consent of school.

Transcriptional, translational and posttranslational control of gene expression in cell differentiation, mechanisms of genomic regulation in eukaryotes, nucleocytoplasmic interactions, genetic aspects of morphogenesis.

Biol. 4466. Genetics of Populations

3-0-3. Prerequisite: Biol. 3334 or consent of school.

Factors determining gene frequency equilibria and changes in populations: selection, mutation, genetic drift, inbreeding, heritability and the nature of genetic variation.

Text: at the level of Mettler and Gregg, *Population Genetics and Evolution*.

Biol. 4468. Molecular Genetics

3-3-4. Prerequisite: Biol. 3334.

Molecular genetics, with special emphasis on the study of nucleic acid structure and function and bacterial and viral structure and function.

Text: at the level of Watson, *Molecular Biology of the Gene*.

Biol. 4470. Biophysical Genetics

3-0-3. Prerequisite: Biol. 3334.

Current research on the biophysical mechanisms of replication, transcription and translation.

Biol. 4476. Supramolecular Biology

3-0-3. Prerequisite: Biol. 2211, Chem. 3313 and Phys. 2123 or consent of school.

Structure, formation and properties of biological objects at a level of organization between single molecules and cells.

Biol. 4478. Physical Biology

4-0-4. Prerequisite: Phys. 2121, Chem. 3312 or consent of school.

Use of physics and biochemistry in explaining structure and function of biological systems at atomic and molecular levels. Approach mathematical, quantum mechanics introduced as needed.

Biol. 4774. Applications of Microbiology in Sanitary Engineering

3-3-4. Prerequisite: senior standing, fall quarter.

Microbiology in environmental engineering. Relationships of protozoa, algae, bacteria and viruses to water borne disease, the treatment of wastes and the deterioration of aquatic habitats.

Biol. 4801-2-3-4-5. Special Topics

1-0-1 to 5-0-5 respectively.

These courses enable the School of Biology to provide offerings dealing with areas of particular current interest in biological science.

Biol. 4960-1-2. Special Problems

Hours to be arranged. Prerequisite: Biol. 2211.

Special laboratory problems in biology, to be given any quarter with credits (not to exceed six) to be arranged.

Biol. 6608. Advanced Microbial Genetics

3-0-3. Prerequisite: Biol. 4408 or 4468 or consent of department.

Genetics of bacteria, plasmids and viruses. Organization and regulation of expression of genetic material, with special emphasis on new techniques such as genetic engineering.

Text: at the level of Stent and Calendar, *Molecular Genetics*, (2nd Ed.).

Biol. 6609. Advanced Microbial Genetics Laboratory

0-6-2. Prerequisite: Biol. 4408 or consent of department.

Production, isolation and characterization of mutants. Testing for mutagens. Text: at the level of Stent and Calendar, *Molecular Genetics*, (2nd Ed.).

Biol. 6611. Advanced Microbial Physiology

3-0-3. Prerequisite: Biol. 4409 or Chem. 3511 or consent of school.

Advanced studies of selected aspects of the physiology of prokaryotic and eukaryotic microorganisms.

Text: Selected references.

Biol. 6619. Ecological Systems

3-0-3. Prerequisite: graduate standing or consent of school.

Fundamentals of ecology with emphasis on the structure and function of ecosystems. Appli-

cation of ecosystem concepts to environmental impact analysis and environmental management. Designed primarily for planners and engineers; suitable for biologists.

Biol. 6622. Special Topics in Ecology

1-2-2. Prerequisite: Biol. 6619 or consent of school.

Topics of current interest in environmental science such as systems analysis, indicators of pollution, environmental impact evaluation and environmental monitoring.

Biol. 6624. Systems Ecology

3-0-3. Prerequisite: Biol. 3335 or equivalent.

The use of systems analysis techniques in ecology. Major emphasis on characterization, analysis and simulation of complex ecosystems. Compartment models, energy circuit models, experimental components models and feedback dynamics models.

Biol. 6625. Communities and Ecosystems

3-0-3. Prerequisite: Biol. 3335 or consent of school.

Theoretical and practical aspects of the description, analysis, classification and current understanding of the functional processes in major communities and ecosystems of North America.

Text: Literature, references and review articles.

Biol. 6626. Physiological Ecology

3-3-4. Prerequisite: Biol. 3335 and either Biol. 4444 or 4445 or consent of school.

Physiological adaptations of plants and animals to their environments. Measurements and analysis of environmental factors as well as organismal physiological responses to light, temperature, water and mineral nutrients will be emphasized.

Text: Literature, references and review articles.

Biol. 6632. Design of Experiments in Quantitative Biology

3-3-4. Prerequisite: Biol. 3332.

The philosophical and statistical basis for design of experiments in biology. Selected examples from the research of individual staff members will serve to demonstrate the basic principles.

Biol. 6633. Selected Topics in Radiobiology

3-3-4. Prerequisite: Biol. 4415.

High-energy radiation as an investigative tool including determination of cell structure and function, target theory and multihit phenomena.

Biol. 6634. Selected Topics in Experimental Cell Biology

3-3-4. Prerequisite: Biol. 6633.

Research areas in microbiology and mammal-

ian cell culture, including permeability of cell membranes, cytogenetics and selection pressures in cell cultures.

Biol. 6635. Air Pollution Biology

3-0-3. Prerequisite: consent of school.

Designed to acquaint engineers and scientists with the biological aspects of air pollution as one factor in the total environment of living animals and plants.

Biol. 6640. Instrumental Methods in Biology

3-6-5. Prerequisite: consent of school.

Biophysical and biochemical methods for the study of macromolecules, cell components, multicellular and organism level organization. Analysis by spectroscopy, centrifugation and other methods.

Biol. 6641. Electron Microscopy Laboratory

0-6-2.

Techniques for the fixation, staining and sectioning of biological materials.

Biol. 6645. Photobiology

3-0-3. Prerequisite: graduate standing or consent of school.

The interactions of light with biomolecules and the roles of light in the environment, in biology and medicine will be considered. Processes of vision, photomorphology, photosynthesis and photoperiodism will be included.

Text: at the level of *The Science of Photobiology*, K. C. Smith, Ed.

Biol. 6646. Mammalian Physiology

3-3-4. Prerequisite: Biol. 4444 or equivalent or consent of instructor.

Physical, biochemical and biological phenomena underlying organ functions. Integration of physiological processes and basic techniques of physiological analysis.

Biol. 6647. Developmental Physiology

3-6-5. Prerequisite: Biol. 3343, 4444 or equivalents or consent of instructor.

Fetal and maternal organ function, vertebrate organogenesis. Investigations of organogenesis in laboratory animals and of abnormal development induced by teratogenic agents.

Biol. 6648. Mammalian Endocrinology

3-0-3. Prerequisite: Biol. 2211, Chem. 3511 or consent of school.

Systematic treatment of the mammalian endocrine system, including mechanisms of hormone action, methods of hormonal assay, endocrine histology and relationships between neural and endocrine integration.

Text: at the level of Sawin, *The Hormones*.

Biol. 6649. Neurobiology

3-0-3. Prerequisite: Chem. 3313, Phys. 2123, Biol. 2211 or consent of school.

A survey of some of the basic mechanisms of neural function and methods used to study them, with particular reference to the visual system.

Text: at the level of Katz, *Nerve, Muscle, and Synapse*, selections from Schmitt, *The Neurosciences*, *Second Study Program*, and references.

Biol. 6664. Selected Topics in Regulatory Biology

3-0-3. Prerequisite: Biol. 3334, Chem. 3351 or consent of school.

"Second messengers," cyclic AMP-prostaglandin interactions, positive and negative transcriptional control in prokaryotes, cyclic AMP and catabolite repression, transcriptional regulation in eukaryotes.

Biol. 6676. Advances in Supramolecular Biology

3-0-3. Prerequisite: Biol. 2211, Chem. 3511 or Phys. 4251, and Phys. 2123 or consent of school.

Advanced treatment of the organization and assembly of biological structures at a level of complexity between single molecules and cells (membranes, viruses, ribosomes).

Text: Selected references.

Biol. 6711. Medical Physiology

5-0-5. Prerequisite: graduate standing, introductory biology or consent of school.

Systematic study of mammalian and particularly of human physiology and essential anatomy, designed for advanced students in fields interdisciplinary with the life sciences. Credit not available for biology majors.

Text: at the level of Ganong, William F., *Review of Medical Physiology*.

Biol. 6730. Biological Effect of Radiations

3-3-4. Prerequisite: consent of school.

An introduction to the effects of nuclear radiations upon biological systems for graduate students in the nuclear science and engineering curriculum.

Biol. 7000. Thesis

Biol. 8013-4-5. Seminar in Microbiology

2-0-2 each. Prerequisite: graduate standing.

Recent advances in microbial physiology and metabolism, industrial and applied microbiology, microbial ecology, medical microbiology and immunology.

Biol. 8023-4-5. Seminar in Ecology

2-0-2 each. Prerequisite: graduate standing.

Topics of current interest and recent advances

in the general areas of population growth and limitation, interspecific relationships and the structure, productivity and stability of ecosystems.

Biol. 8043-4-5. Seminar in Physiology

2-0-2 each. Prerequisite: graduate standing.

Current concepts of membrane structure, molecular and ionic transport mechanisms, endocrinology, cardiac, nervous and muscular function, physiology of development. Student and faculty presentations.

Biol. 8063-4-5. Seminar in Genetics

2-0-2 each. Prerequisite: graduate standing.

Topics of current interest in the areas of cytogenetics, developmental genetics, molecular genetics, mutagenesis and the genetics of man and populations. Student and faculty presentations.

Biol. 8101-2-3-4-5. Special Topics

1-0-1 to 5-0-5 respectively.

These courses enable the School of Biology to provide offerings dealing with areas of particular current interest in biological science.

Biol. 8504-5-6. Special Problems

Credit to be arranged.

BUILDING CONSTRUCTION

See Architecture.

CERAMIC ENGINEERING

Cer.E. 1010. Introduction to Ceramic Engineering

2-3-3. Elective for freshmen.

A comprehensive survey of ceramic materials, raw materials and the industrial processes used in their production.

Text: at the level of Mitchell, *Ceramics—Stone Age to Space Age*.

Cer.E. 3001. Ceramic Data Handling

2-3-3.

Study of testing, rational economic value of test results, basis of test selection, interpretation of results, data analysis, statistical methods, computer methods, reporting.

Text: at the level of Bivington, *Data Reduction and Error Analysis for the Physical Sciences* and Holscher, *Simplified Statistical Analysis*.

Cer.E. 3002. Properties of Engineering Materials

2-3-3. Prerequisite: Chem. 1101 or equivalent.

Introduction to types of materials available to engineers, their properties, the causes of these properties and how these properties determine their utilization and service life.

Text: at the level of Van Vlack, *Elements of Materials Science* and Kingery, *Introduction to Ceramics*.

Cer.E. 3003. Ceramic Processing I

3-3-4. Prerequisite: Chem. 1102 or equivalent.

Processing of ceramic articles based on clay minerals or plastic forming processes.

Text: at the level of Jones, *Ceramics*.

Cer.E. 3004. Ceramic Processing II

2-3-3. Prerequisite: Cer.E. 3003.

Forming processing of nonplastic technical and fine-grained ceramic materials.

Text: at the level of Kingery, *Ceramic Fabrication Processes*.

Cer.E. 3005. Phase Equilibria for Ceramists

3-0-3. Prerequisite or corequisite: Chem. 3412.

Interpretation of phase equilibria in nonmetallic high temperature one, two and three component systems. Usefulness of phase diagrams in the processing of ceramic materials considered.

Text: at the level of Levin, Robbins and McMurdie, *Phase Diagrams for Ceramists* (monography by the American Ceramic Society).

Cer.E. 3006. Physical Ceramics I

3-0-3. Prerequisite: Cer.E. 3002.

Crystal chemistry concepts are developed and used to characterize silicate, oxide and nonoxide ceramic materials.

Text: at the level of Kingery, *Introduction to Ceramics*.

Cer.E. 3007. Pyrometry and Thermal Analysis

2-3-3. Prerequisite: Phys. 2122.

Temperature measurement using thermocouples, optical pyrometers and radiation pyrometers is emphasized. Differential thermal analysis and thermogravimetric analysis in characterizing ceramic materials is presented.

Text: at the level of *Precision Measurement and Calibration*: volume two, *Temperature*, NBS Special Publication 300.

Cer.E. 3008. Glass Technology I

2-3-3. Prerequisite: Cer.E. 3005 or consent of school.

The fundamentals of glass structure, composition, manufacturing, properties and applications are described. In the laboratory many glass batches are melted and analyzed.

Text: at the level of Hutchins and Harrington,

Glass, (reprint from volume 10, *Encyclopedia of Chemical Technology*, second edition, pp. 533-604, J. Wiley, 1966).

Cer.E. 3080. Survey of Ceramics
2-0-2.

General elective for nonmajors. A survey of the classifications and physical properties of ceramic products, the materials and manufacturing processes.

Text: at the level of Mitchell, *Ceramics—Stone Age to Space Age*.

Cer.E. 3090. Ceramic Survey Laboratory
0-3-1. Prerequisite or corequisite: Cer.E. 3080.

General elective. Plant trips to local ceramic plants; flowsheets of processes, production of simple pottery and ceramic pieces.

Cer.E. 4002. Refractories and Combustion
3-3-4. Prerequisite: Cer.E. 3006, Chem. 3412.

Fundamentals of refractory material selection and application are stressed. The raw materials for manufacturing refractories and the engineering of refractory walls are covered.

Text: at the level of Shaw, *Refractories and Their Uses*, and the *North American Combustion Handbook*.

Cer.E. 4003. Physical Ceramics II
2-3-3. Prerequisite: Cer.E. 3006, Phys. 2123, Chem. 3413.

Densification sintering and reaction kinetics active in ceramic materials are considered. The resultant physical, mechanical, electric and magnetic properties are related to the atomic and macroscopic structure representative of ceramic products.

Text: at the level of Kingery, *Introduction to Ceramics*.

Cer.E. 4004. High Temperature Thermodynamics
2-0-2. Prerequisite: Chem. 3412.

Chemical thermodynamics data is used to predict reaction directions and study vaporization processes. The use of various gas mixtures to control oxygen pressures is also described.

Text: at the level of Wicks and Block, *Thermodynamic Properties of 65 Elements—Their Oxides, Halides, Carbides and Nitrides*. Bureau of Mines Bulletin No. 605 (1963).

Cer.E. 4005. Glass Technology II
2-3-3. Prerequisite: Cer.E. 3008.

Compositions of low, moderate and high temperature coatings are studied to learn basis of glass properties, adherence, color, opacification and texture.

Text: at the level of C. W. Parmelee, *Ceramic Glazes*.

Cer.E. 4010-1-2. Technical Management and Design Problems

1-3-2, 0-6-2, 0-3-1. Prerequisite: consent of school.

Major experimental or equipment design is selected by class from a number of problem areas presented by industry.

Cer.E. 4015. Independent Research Project I
1-0-1. Prerequisite: senior standing in ceramic engineering.

The object of this course is to place the student on his or her own initiative and to coordinate the knowledge previously received.

Cer.E. 4016. Independent Research Project II
1-3-2. Prerequisite: Cer.E. 4015.

The senior student formulates an experimental plan under supervision of instructor, assembles equipment and materials and begins actual laboratory experimentation.

Cer.E. 4017. Independent Research Project III
0-6-2. Prerequisite: Cer.E. 4016.

Completion of all laboratory work on investigation, submission of approved write-up in acceptable format one week before examination week.

Cer.E. 4018. Drying and Psychrometry
2-0-2. Prerequisite: Phys. 2122.

Fundamental consideration of water removal from unfired ceramic products by heat and air.

Text: at the level of Moody, *Drying*.

Cer.E. 4042-3-4. Seminar
1-0-1. Prerequisite: junior standing.

Discussion of current ceramic and scientific literature and reports of investigations.

Cer.E. 4051. Cements
2-3-3. Prerequisite: Cer.E. 3005.

Includes the required properties of raw materials, processing and the hydraulic properties of cements. Portland, magnesia, high alumina, dental and gypsiferous cements are included.

Text: at the level of Bogue, *The Chemistry of Portland Cement* or Lea, *The Chemistry of Cement and Concrete*.

Cer.E. 4052. Inorganic Phase Analysis and Identification

3-3-4. Prerequisite: Phys. 2122.

Provides the student with the tools to identify a ceramic material using both atomic structure related techniques and elemental identification. Use of optical crystallography, X-ray diffraction, transmitted and reflected light microscopy and electron microscopy are emphasized as tools to identify ceramic material phases and elemental composition.

Text: at the level of Bloss, *An Introduction of*

the Methods of Optical Crystallography and Culley, *Elements of X-ray Diffraction*.

Cer.E. 4053. Technical Ceramics
2-3-3. Prerequisite: Cer.E. 3006, Phys. 2122.

Fabrication requirements, property control and structure—property—processing relationships, ceramic dielectrics, ferrites, ferroelectrics, piezoelectrics emphasized.

Text: at the level of F. H. Norton, *Fine Ceramics* and E. C. Henry, *Electronic Ceramics*.

Cer.E. 4801-2-3-4-5. Special Topics
Credit by arrangement (1, 2, 3, 4 or 5 hours). Prerequisite: consent of school.

New developments in ceramic materials, specialized independent study on topics of current interest.

Cer.E. 6011. Colloidal Properties of Hydrous Alumino Silicates

3-0-3. Prerequisite: consent of school.

The physicochemical properties of the plastic and nonplastic hydrous alumino silicate are studied including viscosity, dispersion, flocculation and permeability.

Text: at the level of Van Olphen, *An Introduction to Clay Colloid Chemistry*.

Cer.E. 6012. Colloidal Properties of Hydrous Alumino Silicates

3-3-4. Prerequisite: consent of school.

Plastic properties of clay-water systems and industrial applications. Interactions of clays and organic compounds.

Text: at the level of Lawrence, *Clay-Water Systems*.

Cer.E. 6013. Colloidal Properties of Hydrous Alumino Silicates

3-0-3. Prerequisite: consent of school.

Basic surface properties are studied for application to gas absorption surface area measurements and mineral flotation processes.

Cer.E. 6014-5. Ceramic Applications to the Phase Rule

3-0-3 each. Prerequisite: Cer.E. 3005 or consent of school.

Phase equilibria in one, two and three-component systems reviewed. Melting and solidification behavior in complex three-component systems examined. Effect of oxygen pressure on phase relations in multicomponent systems surveyed. Applications of thermodynamics to phase diagrams.

Text: at the level of Prince, *Alloy Phase Equilibria*.

Cer.E. 6017-8. Glass Technology
3-0-3 each.

Constitution of glass is studied using dynamic considerations. The reasons for the failure of oxide melts to crystallize on cooling are emphasized. Mutual polarization of ions is utilized in analyzing the various glass structures. The different experimental techniques available to study glasses are reviewed.

Text: at the level of Weyl and Marboe, *The Constitution of Glasses: A Dynamic Interpretation*.

Cer.E. 6030. Crystal Structure of Materials
3-0-3. Prerequisite: consent of school.

Basic crystal structures and relation of different chemical compounds with similar crystal structures. Structures of various clays and complex oxides.

Text: at the level of Evans, *Crystal Chemistry* and Wells, *Structural Inorganic Chemistry*.

Cer.E. 6031. Crystal Structure of Materials
3-0-3. Prerequisite: consent of school.

Relationship of crystal structure to chemical, physical and optical properties of high temperature inorganic materials.

Cer.E. 6035. Research and Control Methods
2-3-3. Prerequisite: consent of school.

Emphasis on the experimental and instrumental techniques for research and control measurements. Review of optical, physical, electrical, mechanical measurement techniques, instrumentation, laboratory demonstration.

Text: at the level of Wilson, *Introduction to Scientific Research* and Ackoff, *Scientific Method*.

Cer.E. 6041. Crystal Studies
2-6-4. Prerequisite: Cer.E. 4003 or consent of school.

Fundamentals, methods and instruments in applications at X-ray diffraction especially the powder method to problems in ceramics and metallurgy.

Text: at the level of Azaroff, *Elements of X-ray Crystallography*.

Cer.E. 7000. Master's Thesis

Cer.E. 8001-2-3-4-5-6. Seminar
1-0-0.

Current ceramic developments.

Cer.E. 8102 through 8119. Special Topics
Credit to be arranged.

Specific, well-defined study and measurement problems will be considered and approved for credit upon completion.

Cer.E. 8501-2-3. Special Problems
Credit to be arranged.

Cer.E. 9000. Doctoral Thesis.

CHEMICAL ENGINEERING

Chemical Engineering

Ch.E. 1101. Introduction to Chemical Engineering

1-0-1. For freshmen only or consent of school.
An orientation to chemical engineering. Nature of chemical engineering, the types of opportunities available and the requirements for graduation and a successful career.

Ch.E. 1110. Elements of Chemical Engineering Design

2-3-3. For freshmen only or consent of school.
An introduction to chemical engineering design in which simplified problems of current interest are used as a basis for a design project.

Text: At the level of Peters, *Elementary Chemical Engineering*.

Ch.E. 1750. Introduction to Bioengineering

3-0-3.
An introduction to the aspects of science and technology pertinent to the engineering analysis of biological systems. Also taught as A.E. 1750, E.E. 1750, E.S.M. 1750, M.E. 1750.

Ch.E. 2207. Chemical Process Principles I

3-0-3. Prerequisite: Math 1309. Corequisite: Chem. 2113.
The material balance is developed. Gas behavior, systems of units, and material and thermodynamic properties are discussed. Emphasis is on the application of material balances to steady state physical and chemical processes.

Text: At the level of Felder and Rousseau, *Elementary Principles of Chemical Process*.

Ch.E. 2208. Chemical Process Principles II

3-0-3. Prerequisite: Ch.E. 2207.
A continuation of Ch.E. 2207. The energy balance is developed. Thermophysical and thermochemical concepts are discussed. Emphasis is on the application of combined material and energy balances to steady and unsteady state physical and chemical processes.

Text: At the level of Felder and Rousseau, *Elementary Principles of Chemical Process*.

Ch.E. 2209. Computers in Chemical Engineering

2-3-3. Prerequisite: Math. 2308. This course is a

prerequisite to all Jr. and Sr. Ch.E. courses.

Basics of FORTRAN programming. Numerical methods are introduced and applied on the digital computer to the solution of chemical engineering problems.

Ch.E. 3300. Transport Phenomena I

3-0-3. Prerequisite: Math. 2308. Corequisite: Ch.E. 2208.

Fundamental principles of momentum and energy transfer are developed. Applications of these principles are stressed.

Text: At the level of Bird, Stewart and Lightfoot, *Transport Phenomena*.

Ch.E. 3301. Transport Phenomena II

3-0-3. Prerequisites: Ch.E. 2208, Ch.E. 3300.

Mass transfer. Major emphasis is placed on applications involving heat and mass transfer.

Text: At the level of Bird, Stewart and Lightfoot, *Transport Phenomena*.

Ch.E. 3302. Transport Phenomena Laboratory I

0-3-1. Prerequisite: Ch.E. 3300.

Laboratory experiments in momentum and energy transfer.

Ch.E. 3303. Transport Phenomena Laboratory II

0-3-1. Prerequisite: Ch.E. 3301.

Laboratory experiments in heat and mass transfer.

Ch.E. 3306 Unit Operations I

3-0-3. Prerequisite: Ch.E. 3300. Corequisite: Ch.E. 3301.

The analysis of chemical engineering processes and operations involving fluid and heat transfer.

Text: At the level of McCabe and Smith, *Unit Operations of Chemical Engineering* and Perry, *Chemical Engineer's Handbook*.

Ch.E. 3307. Unit Operations II

3-0-3. Prerequisites: Ch.E. 3300, Chem. 3412. Stagewise operations.

Text: At the level of McCabe and Smith, *Unit Operations of Chemical Engineering* and Perry, *Chemical Engineer's Handbook*.

Ch.E. 3308. Unit Operations III

3-0-3. Prerequisites: Ch.E. 3301, Chem. 3412.

Diffusional processes, including combined mass and heat transfer.

Text: At the level of Perry, *Chemical Engineer's Handbook* and McCabe and Smith, *Unit Operations of Chemical Engineering*.

Ch.E. 3309. Unit Operations Laboratory I

0-3-1. Prerequisite: Ch.E. 3307.

Laboratory experiments in stagewise operations.

Ch.E. 3310. Unit Operations Laboratory II

0-3-1. Prerequisite: Ch.E. 3308.

Laboratory experiments in diffusional processes.

Ch.E. 4111. Mineral Engineering: Fossil Fuels

3-0-3.
An introductory course in fossil fuels. Gives majors in engineering a background in fuels as raw materials.

Ch.E. 4414. Air Pollution Control

3-0-3.

Application of mass transfer principles to the design of pollution control systems utilizing adsorption, absorption, filtration and precipitation. Other topics are process optimization, fuel pretreatment.

Text: At the level of Wark and Warner, *Air Pollution—Its Origin and Control*.

Ch.E. 4415. Reactor Design

3-0-3. Prerequisite: Ch.E. 4438, Chem. 3313, 3413.

Kinetics and mechanisms of industrial chemical reactions. Effects of temperature, pressure and concentrations on the rates of chemical reactions. Design of batch backmix, tubular and semibatch reactors.

Text: At the level of Levenspiel, *Chemical Reaction Engineering*.

Ch.E. 4416. Process Control

3-3-4. Prerequisite: E.E. 3700. Corequisite: Ch.E. 4415.

Dynamics of chemical processes and theory of control techniques. Mathematics using primarily Laplace transforms is applied with instrumentation and process constraints to system design.

Text: At the level of Weber, *An Introduction to Process Dynamics and Control*.

Ch.E. 4431. Chemical Engineering Economics

3-0-3. Prerequisite: Ch.E. 3306. Corequisites: Ch.E. 3307, 3308.

A study of techniques required in project analysis in areas of systems cost analysis and the use of the economic balance for design and optimization.

Text: At the level of Peters and Timmerhaus, *Plant Design and Economics for Chemical Engineers*.

Ch.E. 4432. Process and Equipment Design

2-3-3. Prerequisites: Ch.E. 3306, 3307, 3308.

Comprehensive problems for selected types of chemical process equipment. Pressure vessels,

heat exchangers, mass transfer equipment or materials handling equipment.

Text: At the level of Peters and Timmerhaus, *Plant Design and Economics for Chemical Engineers*.

Ch.E. 4434. Chemical Plant Design

1-6-3. Prerequisites: I.C.S. 2250 and all other required Ch.E. courses.

A comprehensive problem in plant design.

Ch.E. 4438. Chemical Engineering Thermodynamics

4-0-4. Prerequisites: Ch.E. 2208, Chem. 3412.

Principles of thermodynamics with industrial applications. Flow of compressible fluids, thermodynamic properties, charts, tables, power and refrigeration cycles and processes, phase equilibria, chemical equilibria.

Ch.E. 4449. Computer Aided Process Design

2-3-3. Prerequisite: Ch.E. 2209, 4438 or consent of school.

A study of the synthesis and operation of large-scale computer systems for steady-state simulation of chemical processes as a design tool.

Text: At the level of Seader, *Flowtran Simulation—An Introduction*.

Ch.E. 4453. Polymerization Process Analysis

3-0-3. Prerequisite: Met. 3301, Ch.E. 4415 or consent of school.

Polymerization processes are analyzed with regard to reaction mechanisms, kinetics and reactor design. Methods of controlling polymer structure during polymerization are emphasized.

Ch.E. 4455. Plastics Industry Manufacturing Policy

3-0-3. Prerequisite: consent of school.

Case studies of practical problems contributed by industry concerning plastics manufacturing, marketing and management. Decision-making processes in the plastics industry are emphasized.

Text: At the level of Skinner and Rogers, *Manufacturing Policy in the Plastics Industry*.

Ch.E. 4750. Polymer Science and Engineering I

3-0-3. Prerequisite: Chem. 1102, Phys. 2123.

An introduction to the chemistry and structure of polymers. Polymerization processes, major polymer systems and methods of polymer identification are presented. Also taught as Text. 4750.

Text: At the level of Rodriguez, *Principles of Polymer Systems*.

Ch.E. 4751. Polymer Science and Engineering II

3-0-3. Prerequisite: Chem. 1102, Phys. 2123.

An introduction to the physical states and transitions, fabrication processes and mechanical properties of polymers. Also taught as Text. 4751.

Text: At the level of Rodriguez, *Principles of Polymer Systems*.

Ch.E. 4752. Polymer Science and Engineering Laboratory

0-3-1. Corequisite: Ch.E. 4751.

Experiments in polymerization, processing and property evaluation of polymers. Also taught as Text. 4752.

Ch.E. 4753. Survey of Pulp and Paper Technology

3-0-3.

A survey is made of the mechanical systems used in paper manufacture. The chemistry of pulp preparation and nonfibrous additives is outlined. Also taught as Text. 4753.

Ch.E. 4771. Pulp and Paper Processes I

3-0-3. Prerequisite: consent of school.

A survey of the processes in a kraft pulp mill necessary to convert raw material to sulfate pulp. Wood preparation, wood chemistry and morphology. The chemical and mechanical characteristics of kraft pulping and chemical recovery processes. Also taught as M.E. 4771.

Ch.E. 4772. Pulp and Paper Processes II

3-0-3. Prerequisite: consent of school.

The major pulping processes other than kraft pulping. General knowledge of the various factors affecting each pulping process and pulp bleaching. The unique advantages and disadvantages of each pulping and bleach process. Also taught as M.E. 4772.

Ch.E. 4773. Paper Formation and Properties

3-0-3. Prerequisite: consent of school.

The processes in the fabrication of paper and paper products from pulp. The effects on paper properties of chemical and mechanical pretreatment of pulp. The measurement of paper properties. Also taught as M.E. 4773 and Text. 4773.

Ch.E. 4774. Pulp and Paper Mill Emission Control

3-0-3. Prerequisite: consent of school.

Methods for control of gaseous, liquid and solid wastes from pulp and paper mill operations. Major biological, chemical and physical methods for treatment of waste streams.

Ch.E. 4800. Special Topics

3-0-3. Prerequisite: consent of school.

Topics relevant to chemical engineering are presented as demand or interest warrants.

Ch.E. 4901-2-3. Special Problems

Credit to be arranged. Prerequisite: Ch.E. 3301.

The student is given an opportunity to develop initiative and to apply fundamental principles by doing semioriginal laboratory or theoretical investigation of a chemical engineering problem.

Ch.E. 6601. Chemical Engineering Thermodynamics I

3-0-3. Prerequisite: Ch.E. 4438 or consent of school.

The laws of thermodynamics with particular application to pure substances. Equations of state, thermodynamic functions of gases and liquids, thermodynamic charts and networks, engineering applications.

Ch.E. 6602. Chemical Engineering Thermodynamics II

3-0-3. Prerequisite: Ch.E. 6601 or consent of school.

Thermodynamics of solutions. Ideal and non-ideal nonelectrolyte solutions. Phase equilibria involving gas, liquid and solid phases. Molecular properties of liquid and liquid mixtures. Engineering applications.

Ch.E. 6603. Chemical Engineering Thermodynamics III

3-0-3. Prerequisite: Ch.E. 6602 or consent of school.

Thermodynamic equilibrium including chemical equilibrium. Statistical thermodynamics. Third law of thermodynamics. Heat capacities at low and high temperatures. Ionic solids and solutions. Engineering applications.

Ch.E. 6604-5-6. Organic Chemical Technology

3-0-3 each. Prerequisite: Chem. 3313.

Important organic chemical processes and their combinations are studied with emphasis on more recent developments.

Ch.E. 6610. Aerosol Technology

3-0-3. Prerequisite: consent of school.

Presents basic concepts describing the behavior of dispersed particles. Includes generation, sampling and size analyses, diffusion, coagulation, settling, kinetics and dynamics, electrostatic and optical properties.

Text: At the level of Mercer, *Aerosol Technology*.

Ch.E. 6611. Industrial Emission Control

3-0-3. Prerequisite: consent of school.

Air quality criteria, ambient and emission standards and industrial sources are analyzed. Recovery and utilization of waste gaseous and particulate matter is presented.

Text: At the level of Crawford, *Air Pollution Control Theory*.

Ch.E. 6612. Atmospheric Reactions

3-0-3. Prerequisite: consent of school.

The principles of atmospheric chemical and photochemical reactions, including primary and derived air pollutants, sources and sinks of carbon, nitrogen, sulfur and oxygen compounds.

Text: At the level of Seinfeld, *Air Pollution, Physical and Chemical Fundamentals*.

Ch.E. 6613. Technology of Fine Particles

3-0-3. Prerequisite: Ch.E. 3301 or consent of school.

An examination of the properties of finely divided materials. Size, surface, pores are treated in relation to reactivity, adsorptivity, catalytic behavior and process engineering operations.

Text: At the level of Allen, *Particle Size Measurement*.

Ch.E. 6615. Transport Phenomena I

3-0-3. Prerequisite: Ch.E. 3301 or consent of school.

Advanced theory and applications of momentum transport.

Text: At the level of Bird, Stewart and Lightfoot, *Transport Phenomena*.

Ch.E. 6616. Transport Phenomena II

3-0-3. Prerequisite: Ch.E. 6615 or consent of school.

Advanced theory and applications of energy transport.

Text: At the level of Bird, Stewart and Lightfoot, *Transport Phenomena*.

Ch.E. 6617. Transport Phenomena III

3-0-3. Prerequisite: Ch.E. 6616 or consent of school.

Advanced theory and applications of mass transport.

Text: At the level of Bird, Stewart and Lightfoot, *Transport Phenomena*.

Ch.E. 6619. Chemical Engineering Calculations I

3-0-3. Prerequisite: Ch.E. 3308, Math. 2308.

A study of the application of classical mathematical methods (including Laplace transforms and Bessel functions) to the solution of typical chemical engineering problems.

Text: At the level of Jenson and Jeffreys, *Mathematical Methods in Chemical Engineering*.

Ch.E. 6620. Chemical Engineering Calculations II

3-0-3. Prerequisite: Ch.E. 6619 or consent of school.

A study of the application of modern mathematical techniques (including numerical methods and optimization procedures) to the solution of typical chemical engineering problems.

Text: At the level of Jenson and Jeffreys, *Mathematical Methods in Chemical Engineering*.

Ch.E. 6622. Advanced Reactor Design

3-0-3. Prerequisite: Ch.E. 4415.

A study of chemical kinetics and mechanisms in complex homogeneous and heterogeneous reaction systems. Design of chemical reactors for such systems.

Text: At the level of Smith, *Chemical Engineering Kinetics*.

Ch.E. 6628. Advanced Unit Operations I

3-0-3. Prerequisite: Ch.E. 3308.

Flow through conduits, metering of fluids, mixing of liquids, flow and heat transfer in heat exchangers, packed columns and fluidized beds.

Ch.E. 6629. Advanced Unit Operations II

3-0-3. Prerequisite: Ch.E. 3308.

Thermal radiation in furnaces, measurement of elevated temperatures, condensation of mixed vapors and evaporation.

Text: At the level of McAdams, *Heat Transmission*.

Ch.E. 6635. Advanced Unit Operations III

3-0-3. Prerequisite: Ch.E. 3308.

Vapor liquid equilibrium and separation by distillation of binary and multicomponent mixtures. Factors influencing design and performance of fractionating equipment. Application of azeotropic and extractive distillation.

Text: At the level of Robinson and Gilliland, *Elements of Fractional Distillation*.

Ch.E. 6637. Advanced Unit Operations IV

3-0-3. Prerequisite: Ch.E. 3308 or consent of school.

An advanced study of adsorption and stripping in simple and in multicomponent systems. Designs and performance of equipment. Solid-liquid and liquid-liquid extraction.

Ch.E. 6646. Economic Analysis of Chemical Engineering Processes

3-0-3. Prerequisite: graduate standing.

Analysis of chemical engineering problems from the economic standpoint. Economic balance as a controlling factor in equipment design and operation.

Ch.E. 6648-9. Chemical Plant Design

1-6-3 each. Prerequisite: Ch.E. 4434 or consent of school.

Selected methods of chemical plant design.

Ch.E. 6750. Polymer Structure and Physical Properties I

3-0-3. Prerequisite: consent of school.

Morphology and structure, linear and non-linear viscoelasticity, anisotropic mechanical properties and yield and fracture behavior of polymers with applications to textile fibers and plastic products. Also taught as Text. 6750.

Text: At the level of Ward, *Mechanical Properties of Solid Polymers*.

Ch.E. 6751. Polymer Structure and Physical Properties II

3-0-3. Prerequisite: consent of school.

Structure-property relationships of elastomers, reinforced plastics, fibers, foams and natural polymers with emphasis on proteins and the composite nature of all polymers and polymer products. Also taught as Text. 6751.

Text: At the level of Ward, *Mechanical Properties of Solid Polymers*.

Ch.E. 6753. Surface Science and Technology Laboratory

3-18-9. Prerequisite: consent of school.

A highly specialized laboratory course using modern analytical and research instrumentation to characterize and study the surface properties of materials. Also taught as Chem. 6753 and Phys. 6753.

Ch.E. 6775. Advanced Engineering Programming Methods

3-3-4. Prerequisite: FORTRAN programming knowledge.

Advanced engineering programming concepts and their implementation on large scale digital computers. dynamic data, dynamic programs, engineering data management, primary memory management, engineering problem-oriented language development and ICES.

Ch.E. 6787. Heterogeneous Catalysis

3-0-3. Prerequisite: Ch.E. 6622 or consent of instructor.

Physical chemistry of surfaces; thermodynamics, kinetics and mechanism of chemisorption and surface reactions; industrial catalysts. Also taught as Met. 6787.

Text: At the level of Gates, Katzer and Schuit, *Chemistry of Catalytic Processes*.

Ch.E. 7000. Master's Thesis

Ch.E. 7716. Advanced Unit Operations

3-0-3. Prerequisite: Ch.E. 3308.

Fundamental principles underlying diffusional processes. Development of basic relationships from kinetic theory of gases. Application to diffusional processes including eddy diffusion.

Ch.E. 7736. Chemically Reacting Flow Processes I

3-0-3. Prerequisite: Ch.E. 6603, 6617, 6622.

The development of a generalized approach to chemically reacting flow processes. Chemical vapor deposition and catalysis will be considered.

Ch.E. 7737. Chemically Reacting Flow Processes II

3-0-3. Prerequisite: Ch.E. 7736.

A continuation of Ch.E. 7736 to include catalytic and noncatalytic flow reactors, flame reactors and combustion processes.

Ch.E. 7738. Advances in Transport Phenomena

3-0-3. Prerequisite: Ch.E. 6617 or consent of school.

Topics such as multicomponent diffusion, compressible flow with simultaneous heat and mass transfer and chemical reaction and various approximate solution techniques.

Ch.E. 7750. Surface and Solution Properties of Polymers

3-0-3. Prerequisite: consent of school.

Study of plasticized polymers, solutions and colloids: sorption, polymer characterization, interfacial phenomena and coagulation using thermodynamics, statistical mechanics, information and fluctuation theories and relaxation methods. Also taught as Text. 7750.

Ch.E. 7751. Energetics

3-0-3. Prerequisite: consent of school.

Energetics applied to polymers and fibers using Newtonian mechanics, thermodynamics, statistical thermodynamics and quantum mechanics to relate macroscopic and molecular descriptions of processes and materials. Also taught as Text. 7751.

Ch.E. 7752. Kinetics

3-0-3. Prerequisite: consent of school.

Kinetics applied to polymers and fibers including fluid flow, viscoelasticity, heat transfer, diffusion, electrical conductivity, rates of chemical reactions and phase changes and irreversible thermodynamics. Also taught as Text. 7752.

Ch.E. 7753. Polymer Flow

3-0-3. Prerequisite: Ch.E. 6750 or Text. 6750 or consent of school.

The fluid mechanics, heat transfer and mixing of non-Newtonian fluids. Experimental methods for characterizing fluids and the extrusion of polymer melts are emphasized. Also taught as Text. 7753.

Ch.E. 7999. Preparation for Doctoral Qualifying Examinations

Noncredit. Prerequisite: consent of director.

Students who are preparing for their qualifying examinations will be expected to register for this course. Occasionally this may be the only course for which a student is registered.

Ch.E. 8001-2-3. Seminar

1-0-0 each.

A discussion group composed of staff and graduate students, where assigned topics from the literature are discussed as well as research problems in progress.

Ch.E. 8100. Special Topics in Chemical Engineering

3-0-3. Prerequisite: consent of school.

Lectures on special topics of current interest in chemical engineering.

Ch.E. 8500. Special Problems in Chemical Engineering

Credit to be arranged.

Lectures, laboratory and library work on special problems of current interest in chemical engineering.

Ch.E. 9000. Doctoral Thesis

Credit to be arranged.

Metallurgy

Met. 3301. Principles and Applications of Engineering Materials

4-3-5. Prerequisite: Chem. 1101 and 1102 or 1111 and 1112, 2113, Phys. 2123.

The principles of engineering materials directed toward their application in engineering design. Equilibrium and nonequilibrium structures and properties. Corrosion. Engineering application and failure analysis.

Text: At the level of Barrett, Klix and Tetelman, *Principles of Engineering Materials*.

Met. 3325. General Metallurgy

3-0-3. Prerequisite: Chem. 1102, Phys. 2121.

Introductory physical metallurgy and characteristics and engineering applications of cast irons and steels. Static and dynamic properties of metals and alloys. Not open to students in the School of Chemical Engineering.

Text: At the level of Guy, *Physical Metallurgy for Engineers*.

Met. 4110. Mineral Engineering: Introduction to Formation and Accumulation of Mineral Resources

3-0-3.

The processes of formation and accumulation

of ores, industrial minerals and rocks and fuels and an introduction to mining and beneficiation.

Met. 4112. Mineral Engineering: Introduction to Mineral Economics

3-0-3.

Factors pertaining to the economics of the mineral industries and theoretical and pragmatic concerns in the utilization of mineral resources.

Met. 4114. Mineral Engineering: Introduction to Mining

3-0-3. Prerequisite: consent of school.

Evaluation of mining sites; surface and underground mining methods and related equipment. Coal, ores and industrial minerals and rocks. Safety and environmental aspects of mining.

Met. 4115. Mineral Engineering: Economics of the Mineral Industries

3-0-3. Prerequisite: consent of school.

Mineral property titles and concessions, valuation, acquisition and operating costs, marketing, taxation, environmental considerations and the role of minerals in industrialized nations.

Met. 4116. Mineral Engineering: Separation Technology

3-0-3. Prerequisite: junior standing.

A study of the processes for separating mine products and other materials and solid fuels; crushing, grinding, volumetric sizing, classifying and concentration.

Met. 4403. Introductory Nuclear Metallurgy

3-3-4. Prerequisite: Chem. 1102, Phys. 2123.

Fundamentals of physical metallurgy, metal crystals, phase diagrams, properties, fabrication and testing with emphasis on metals used in nuclear reactor systems. Primarily for N.E. students. Not open to Ch.E. students.

Met. 4411. Basic Extractive Metallurgy

3-0-3. Prerequisite: Chem. 3413 or equivalent.

Theory and practice of extraction and refining of ferrous and nonferrous metals. Calculations and reactions related to pyrometallurgical and hydrometallurgical extractive processes will be emphasized.

Text: At the level of Gilchrist, *Extraction Metallurgy*.

Met. 4421. Nonferrous Metallography

2-3-3. Prerequisite: Met. 3301 or equivalent.

The influence of processing variables on the structure and properties on nonferrous alloys. Pyrometric instrumentation applied to heat treating and thermal analysis.

Text: At the level of Gordon and Phillips, *Structure and Properties of Alloys*.

Met. 4422. Ferrous Metallography

3-3-4. Prerequisite: Met. 3301, 4421 or equivalent.

The influence of processing variables on the microstructure and properties of steels and ferrous alloys. Heat treating and thermal analysis of ferrous materials.

Text: At the level of Brick, Gordon and Phillips, *Structure and Properties of Alloys*.

Met. 4423. Metallurgical Fabrication

3-0-3. Prerequisite: Met. 3301 or equivalent.

Primary forming techniques and secondary fabrication and joining processes. Some of the processes to be discussed are casting, rolling, forging, extrusion, drawing, machining and welding.

Met. 4441. Theoretical Physical Metallurgy

3-0-3. Prerequisite: Met. 3301 and Chem. 3413 or equivalent.

A study of the physical and mechanical properties of metals and alloys in the light of their structure.

Text: At the level of Cottrell, *An Introduction to Metallurgy*.

Met. 4445. Electron Microscopy

2-3-3. Prerequisite: Math. 2308 and Met. 3301.

Theory and principles of electron optics and electron microscopy. Preparation and observation of materials by electron microscopy.

Text: At the level of Thomas, *Transmission Electron Microscopy of Metals*.

Met. 4446. X-ray Metallography

3-3-4. Prerequisite: Met. 3301.

Theory and application of X-ray diffraction to metallurgy. Crystal studies, texture studies, phase diagram determination and chemical analysis.

Text: At the level of Cullity *Elements of X-ray Diffraction* and Azaroff and Donahue, *Laboratory Experiments in X-ray Crystallography*.

Met. 4463. Metallurgical Testing

2-3-3. Prerequisite: Met. 3301.

Stress-strain relationships. Elastic and plastic deformation. Elementary dislocation concepts. Laboratory experiments include tension, creep, fatigue, impact and hardness testing. Metallic, ceramic, plastic and filamentary materials.

Met. 4464. Nondestructive Testing

2-3-3.

Principles and theory of industrial nondestructive testing methods. Emphasis on testing the soundness and reliability of primary and secondary fabricated metal structures.

Text: *Nondestructive Testing Handbook*.

Met. 4491. Corrosion and Protective Measures

3-0-3. Prerequisite: Chem. 3413 and Met. 3325 or 3301.

The electrochemical theory of corrosion, recommended materials and protective measures for chemical processing equipment and for atmospheric, underground, underwater and elevated temperature exposures.

Met. 6005. Dental-Medical Materials

2-0-2. Prerequisite: Met. 3301 and Met. 4491.

Theoretical requirements and compatibility of metals as medical implants and a review of up-to-date research. Special lectures will be given by visiting researchers.

Met. 6011. Pyrometallurgy

3-0-3. Prerequisite: Met. 4411 or equivalent.

Pyrometallurgical processes for the production or recycling of ferrous and nonferrous metals.

Met. 6012. Hydrometallurgy

3-0-3. Prerequisite: Met. 4411 or equivalent.

Hydrometallurgical processes used in the production of copper, aluminum, zinc, uranium and other metals.

Met. 6014. Electrometallurgy

2-3-3. Prerequisite: Chem. 3413 or equivalent.

Electrolytic dissolution and deposition of metals, electrolytic purification, electroplating, anodizing and electropolishing.

Met. 6021. Metallurgical Design Problems

1-6-3. Prerequisite: full graduate standing.

Selection of process equipment design of special equipment, plant layouts and preparation of equipment, utilities. Production costs. Design methods are discussed, evaluated and utilized.

Met. 6025. Powder Metallurgy

1-3-2. Prerequisite: Met. 4423.

Physical and chemical production of metallic powders. Pressing, slipcasting, sintering and the theoretical aspects of these processes. Hot pressing and coining. Industrial applications and materials.

Text: At the level of ASM *Powder Metallurgy*, selected literature by Steinburg, Kuczynski and Schwarzkopf.

Met. 6033. High Temperature Metallurgy

2-0-2. Prerequisite: Met. 3301, 4491.

Effects of temperature on properties and microstructures. Deformation mechanisms, theories and phenomenological relationships. Grain boundary sliding, migration. Constitutive equations, deformation mechanism maps, time-temperature parameters.

Text: At the level of F. Garofalo, *Fundamentals of Creep-Rupture in Metals*.

Met. 6035. Advanced Nuclear Materials

3-0-3. Prerequisite: Met. 4403 or equivalent.

Physical metallurgy of alloys used in fission and fusion reactor systems. Response of materials to irradiation. Creep, fracture and corrosion. Design of new alloys.

Met. 6091. Advanced Theory of Metallic Corrosion

3-3-4. Prerequisite: Met. 4491.

The subject matter covers the latest theories and concepts of metallic corrosion.

Met. 6421. Quantitative Characterization of Microstructures

3-0-3. Prerequisite: graduate standing or consent of instructor.

General, statistically-exact methods for describing geometrical attributes of microstructures from random sections. Applications to actual materials or biological specimens. Manual and automatic image analysis techniques.

Met. 6787. Heterogeneous Catalysis

3-0-3.

Physical chemistry of surfaces; thermodynamics, kinetics and mechanisms of chemisorption and surface reactions; industrial catalysts. Also taught as Ch.E. 6787.

Text: At the level of Gates, Katzer and Schuit, *Chemistry of Catalytic Processes*.

Met. 7000. Master's Thesis**Met. 7041. Advanced Physical Metallurgy I**

3-0-3. Prerequisite: Met. 4441.

Thermodynamic and solid state of metals and alloys. Phase stability. Systems for prediction of properties. Lattice dynamics. Electronic properties.

Text: At the level of W. Hume-Rothery, *Atomic Theory for Students of Metallurgy*.

Met. 7045. Advanced Electron Microscopy I

3-0-3. Prerequisite: Met. 7051.

This course will emphasize the dynamical theory of image contrast in thin crystalline foils and its application to the interpretation of lattice defects.

Met. 7046. Advanced Electron Microscopy II

3-0-3. Prerequisite: Met. 4445, 7045.

This course will emphasize the application of theories of electron diffraction and image contrast in thin foils to the types of problems commonly encountered in metallurgy.

Met. 7051. Advanced Mechanical Metallurgy

3-0-3. Prerequisite: Met. 4463.

Basic elasticity theory. General elasticity equations. Applications to dislocations: stresses, forces, displacements, interactions, energies. Origin, multiplication and movement of dislocations. Single-phase, two-phase and particle strengthening.

Texts: G. E. Dieter, *Mechanical Metallurgy*; J. Weertman and J. R. Weertman, *Elementary Dislocation Theory*.

Met. 7052. Advanced Dislocations and Strengthening Mechanisms I

3-0-3. Prerequisite: Met. 7051.

The emphasis in this course will be on dislocation networks and their effect on the mechanical behavior of materials including both monotonic and cyclic properties.

Text: Hertzberg, *Deformation and Fracture Mechanics of Engineering Materials*.

Met. 7053. Advanced Dislocations and Strengthening Mechanisms II

3-0-3. Prerequisite: Met. 7052.

The emphasis in this course will be the interaction of dislocations with other defects and the correlation of these interactions with the mechanical properties of materials including environment's effect on fractures.

Texts: Hertzberg, *Deformation and Fracture Mechanics of Engineering Materials*; *Fatigue and Microstructure*, American Society for Metals.

Met. 7062. Magnetism in Metals

3-0-3. Prerequisite: Phys. 6231, Met. 4441, 7081.

Magnetism in materials. Electron theory, statistical and thermodynamic interpretation of ferro-, antiferro- and helimagnetism. Ferromagnetism in metals and alloys. Domain theory of hysteresis behavior. Anisotropy and magnetostriction. Magnetic measurements.

Met. 7068. Neutron Diffraction

3-0-3. Prerequisite: Phys. 6231, Met. 4441, 4446.

Neutron scattering properties. Neutron diffraction techniques. Analysis of alloy and magnetic structure. Simple structural systems. Reciprocal space and Fourier transform methods. Inelastic scattering by phonons and magnons.

Text: At the level of Bacon, *Neutron Diffraction*, second edition.

Met. 7081. Metallurgical Thermodynamics

3-0-3. Prerequisites: Met. 4441, Chem. 3412.

Chemical thermodynamics of metals, alloys and metallurgical processes. Chemical equilibrium. Solution thermodynamics. Phase equilibria.

Text: Gaskell, *Introduction to Metallurgical Thermodynamics*.

Met. 7085. Metallurgical Kinetics

3-0-3. Prerequisite: Met. 7081.

Heat and mass transport. Empirical kinetics. Phase transformations. Diffusion mechanisms. Nucleation. Growth. Solidification. Recrystallization. Precipitation. Spinodal decomposition. Decomposition of austenite. Radiation damage.

Met. 8001-2-3. Seminar

2-0-1 each. Prerequisite: graduate standing.

The latest advances in metallurgical research and development will be presented by the enrolled students from articles in recent issues of recognized periodicals.

Met. 8100. Special Topics in Advanced Physical Metallurgy

3-0-3. Prerequisite: consent of school.

Representative subjects include alloy theory, phase transformations, magnetic and electric phenomena in metals and special topics in diffusion analysis.

Met. 8500. Special Problems (Master's)

Credit to be arranged.

Lectures, laboratory and library work on special topics of current interest in metallurgy suitable for a master's candidate.

Met. 9000. Doctoral Thesis

Credit to be arranged.

CHEMISTRY

Note: all students are required to wear safety glasses while working in the laboratories. The glasses will be provided at the student's expense.

Chem. 1101-2. General Chemistry

4-3-5 each.

Fundamental laws and theories of chemistry for students who do not plan to take advanced chemistry courses.

Text: at the level of Masterton, Slowinski, *Chemical Principles*.

Chem. 1111-2. General Chemistry

4-3-5 each.

For students planning to pursue advanced courses in chemistry. In depth studies of chemical principles and the techniques of quantitative analysis necessary for further studies in chemistry.

Text: at the level of Waser, *Chem One*.

Chem. 2113. Chemical Principles

3-3-4. Prerequisite: Chem. 1112 or Chem. 1102.

Continuation of Chem. 1112 stressing thermodynamics and kinetics and their applications to chemistry. Quantitative experimentation.

Text: at the level of Waser, *Chem One*.

Chem. 3111-2. Advanced Inorganic Chemistry

4-0-4 each. Prerequisite: Chem. 3411.

A study of the reactions and structures of inorganic compounds and the principles, generalizations and theories which assist in understanding their behavior.

Text: at the level of Huheey, *Inorganic Chemistry*, second edition.

Chem. 3311-2-3. Organic Chemistry

3-0-3 each. Prerequisite: Chem. 2113 or consent of school.

Principal classes of organic compounds, aliphatic and aromatic.

Text: at the level of Morrison and Boyd, *Organic Chemistry*, third edition.

Chem. 3381-2. Organic Chemistry Laboratory

0-6-2 each. Concurrent with or following Chem. 3311-2 respectively; Chem. 3381 prerequisite to Chem. 3382.

Studies of reactions, preparation and the techniques used in the organic laboratory.

Chem. 3385. Organic Chemistry Laboratory

0-12-4. Prerequisite: Chem. 3382. Prerequisite or corequisite: Chem. 3313.

Advanced study of organic reactions, preparations, separations, instrumentations and techniques.

Chem. 3411. Physical Chemistry

3-0-3. Prerequisites: Chem. 2113, Phys. 2122, Math. 2307.

Quantum mechanics and atomic structure, bonding theory, molecular spectroscopy.

Text: At the level of Moore, *Physical Chemistry*.

Chem. 3412. Physical Chemistry

3-0-3. Prerequisites: Chem. 2113, Phys. 2122, Math. 2307.

Chemical thermodynamics, energetics of chemical reactions and changes of state.

Text: At the level of Moore, *Physical Chemistry*.

Chem. 3413. Physical Chemistry

3-0-3. Prerequisite: Chem. 3412.

Electrochemistry, rates of chemical reactions, kinetic theory of gases, statistical mechanics.

Text: At the level of Moore, *Physical Chemistry*.

Chem. 3481. Physical Chemistry Laboratory

0-6-2. Prerequisite: concurrent with or following Chem. 3412.

Applications of physical chemistry principles.

Chem. 3491. Physical Chemistry Laboratory

0-6-2. Prerequisite: Chem. 3481 and concurrent with or following Chem. 4401 or consent of school.

Applications of electronic spectroscopy to vibrational, rotational and electronic properties of simple molecules. Kinetic properties of reacting systems emphasizing molecular, dynamic properties.

Chem. 3511. Biochemistry

3-0-3. Prerequisite: Chem. 3312.

Introductory course in biochemistry dealing with the chemistry and biochemistry of proteins, lipids, carbohydrates, nucleic acids and other biomolecules.

Text: at the level of Lehninger, *Biochemistry*.

Chem. 4181. Synthetic Inorganic Chemistry

0-6-2. Concurrently with or following Chem. 3111.

Preparation and characterization of inorganic compounds, with special emphasis on the apparatus and techniques employed in modern synthetic inorganic chemistry.

Text: at the level of Jolly, *Synthetic Inorganic Chemistry*.

Chem. 4201. Analytical Chemistry for Nonchemists

2-3-3. Prerequisite: Chem. 2113.

Provides a background to modern analytical chemistry and to instrumental methods of analysis with applications to engineering and other areas. Not open to chemistry majors.

Text: at the level of Christian, *Analytical Chemistry*, third edition.

Chem. 4211. Instrumental Analysis I

3-6-5. Concurrent with or following Chem. 3411.

Introduction to both theory and practice of modern instrumental methods: polarography, spectroscopy, colorimetry, microscopy, polarimetry, electroanalytical methods.

Text: at the level of Flaschka, Barnard, and Sturrock, *Quantitative Analytical Chemistry*, volume one.

Chem. 4212. Instrumental Analysis II

3-6-5. Prerequisite: Chem. 4211 or consent of school.

Continuation of Instrumental Analysis I.

Text: at the level of Willard, Merritt and Dean, *Instrumental Methods of Analysis*.

Chem. 4231. Advanced Instrumental Analysis

1-6-3. Prerequisite: Chem. 4211 or consent of school.

Advanced analytical techniques and investigations of newer analytical methods in the practice of analysis.

Chem. 4311-2. Organic Reactions

3-0-3 each. Prerequisite: Chem. 3313.

Theoretical interpretation of reactivity, reaction mechanisms and molecular structures of organic compounds.

Chem. 4341. Applied Spectroscopy

3-0-3. Prerequisite: Chem. 3313.

Interpretation of spectroscopic and other common methods of organic analysis and structure determinations.

Chem. 4401. Physical Chemistry

3-0-3. Prerequisite: Chem. 3411, Phys. 2123 and Math. 2308 or consent of school.

Theory of molecular spectroscopy, electron diffraction, X-ray diffraction, neutron diffraction and magnetic methods applied to the determination of molecular structure.

Chem. 4452. Chemistry of the Solid State

3-0-3. Prerequisite: Chem. 3411 or consent of school.

Applications of the concepts of physical chemistry to the structure of solids and their chemical and physical properties.

Text: at the level of Barrow, *Physical Chemistry*.

Chem. 4511-2. Biochemistry

3-0-3 each. Prerequisite: Chem. 3511 or consent of school.

The chemistry and biochemistry of proteins, lipids, carbohydrates, nucleic acids and other biomolecules.

Text: at the level of Lehninger, *Biochemistry*.

Chem. 4581. Biochemistry Laboratory

0-6-2. Prerequisite: concurrent with or following Chem. 3511.

Laboratory techniques in the isolation and characterization of proteins and nucleic acids with special emphasis on modern practices in biochemistry.

Chem. 4701. Chemistry of Nuclear Technology

3-3-4. For students in nuclear engineering.

Principles of inorganic, radiation and radio chemistries, separation methods for actinide elements and fission products and topics related to production and utilization of nuclear energy.

Chem. 4901-2-3. Special Problems

Credit to be arranged. Prerequisite: consent of school.

Individualized instruction which will include library, conference and laboratory work.

Chem. 5201. Analysis of Atmospheric Contaminants

3-0-3. Prerequisite: Chem. 1102 or 1112, Math. 1309 and Phys. 2123. May not be used by a student for credit towards any graduate degree in chemistry.

Acquaints the student with modern analytical techniques and instrumental methods of analysis including applications involving the measurement of air contaminants.

Text: at the level of Willard, Merrit and Dean, *Instrumental Methods of Analysis* and Jacobs, *The Chemical Analysis of Air Pollutants*.

Chem. 6111-2. Advanced Inorganic Chemistry

3-0-3 each. Prerequisite: consent of school.

The theory of bonding and structure of inorganic compounds and the chemistry of the elements.

Text: at the level of Cotton, Wilkinson, *Advanced Inorganic Chemistry*, third edition.

Chem. 6141. Chemical Applications of Group Theory

3-0-3. Prerequisite: Chem. 3112 or consent of school.

An introduction to basic definitions and theorems of group theory and their application to molecular symmetry and quantum mechanics and use in valence bond, molecular orbital and ligand field treatments.

Text: at the level of Cotton, *Chemical Applications of Group Theory*.

Chem. 6151. Chemical Crystallography

3-0-3. Prerequisite: consent of school.

Application of X-ray diffraction to the determination of crystal structures including crystal symmetry, reciprocal lattice, intensity of diffraction, the phase problem and refinement of structure parameters.

Chem. 6211-2. Analytical Chemistry

3-0-3 each. Prerequisite: consent of school.

Theoretical principles and uses of modern instrumental methods: spectroscopy, microscopy, colorimetry, polarography, polarimetry and electroanalytical methods.

Text: at the level of Flaschka, et al., *Quantitative Analytical Chemistry*, volume one and Willard, et al., *Instrumental Methods of Analysis*.

Chem. 6221. Organic Reagents in Analytical Chemistry

3-0-3. Prerequisite: Chem. 4212.

Chelating agents used in the detection and determination of inorganic ions, spot testing methods and extraction procedures employing organic reagents.

Chem. 6230. Electrochemistry

3-0-3. Prerequisite: consent of school.

A study of electrochemical instrumentation, the thermodynamics, structure, adsorption of the electrical double layer and the kinetics of simple and complex electrode processes.

Chem. 6231. Electroanalytical Chemistry

3-0-3. Prerequisite: Chem. 4212 or consent of school.

Coulometry, electrolytic separations, polarography, chronopotentiometry, coulometric titrations and voltametric methods of equivalence point detection.

Text: at the level of Lingane, *Electroanalytical Chemistry*.

Chem. 6241. Advanced Analytical Chemistry

3-0-3. Prerequisite: consent of school.

Competing equilibria, including polybasic acids, differential precipitation, complex ion formation in competition with these. Complexometric titrations and homogenous precipitation. Adsorption, partition, ion exchange and gas chromatography.

Chem. 6311-2-3. Organic Chemistry

3-0-3 each. Prerequisite: Chem. 3313 and consent of school.

A more advanced study of the fundamental reactions and theories of structure of various classes of organic compounds.

Text: at the level of House, *Modern Synthetic Reactions*, second edition.

Chem. 6321-2-3. Reactivity, Mechanism and Structure in Organic Chemistry

3-0-3 each. Prerequisite: consent of school.

Theoretical interpretations of reactivity, reaction mechanisms and molecular structures of organic compounds.

Chem. 6342. Instrumental Methods of Organic Analysis

3-0-3. Prerequisite: Chem. 3313 or consent of school.

Interpretation of spectroscopic and other common methods of organic analysis and structure determinations.

Chem. 6351. Organometallic Chemistry

3-0-3. Prerequisite: consent of school.

Survey of organometallic chemistry of main group elements, particularly lithium, sodium, beryllium, magnesium, zinc, cadmium, mercury, boron and aluminum, emphasizing structure, bonding, reaction mechanisms and applications.

Chem. 6411-2. Molecular Structure and Chemical Principles

3-0-3 each. Prerequisite: consent of school.

A discussion of molecular structure based upon quantum mechanical principles.

Chem. 6421-2. Chemical Thermodynamics

3-0-3 each. Prerequisite: Chem. 3411-2-3.

Laws of thermodynamics and their chemical applications. Introduction to chemical kinetics and statistical mechanics.

Chem. 6451. Surface Equilibria

3-0-3. Prerequisite: consent of school.

Classical and statistical thermodynamics of surface systems, intermolecular forces at the gas-solid interface, adsorption phenomena and capillarity.

Chem. 6541. Advanced Biophysical Chemistry

3-0-3. Prerequisite: Chem. 3411 and 3412 or consent of instructor.

Applications of the principles and techniques of physical chemistry in biochemistry with emphasis on the equilibrium and dynamic behavior of macromolecules in solution.

Chem. 6610. Nuclear Chemistry

4-0-4. Prerequisite: Chem. 3413 and Math. 2308.

Properties and structure of the atomic nucleus, radioactivity and decay schemes, interaction of radiation with matter, detection and experimental methods, nuclear reactors, radiochemical techniques.

Text: at the level of Evans, *The Atomic Nucleus*.

Chem. 6612. Nuclear Chemistry

3-0-3. Prerequisite: Chem. 6610.

A continuation of Chem. 6610.

Chem. 6621. Fast-neutron Interactions

3-0-3. Prerequisite: Chem. 6612 or consent of school.

Properties of the neutron. Forces between nucleons. Fast neutron sources. Experimental methods of detection, spectrometry and calibration of neutrons and neutron sources.

Chem. 6622. Nuclear Fission

3-0-3. Prerequisite: Chem. 6612 or consent of school.

Theory, probability, mass and charge distributions, fragmentations, low, intermediate and high energy processes and photofission processes occurring in nuclear fissions.

Chem. 6753. Surface Science Laboratory

3-18-9. Prerequisite: consent of school.

A highly specialized laboratory course using

modern analytical and research instrumentation to characterize and study the surface properties of materials.

Chem. 7000. Master's Thesis**Chem. 7121. Ligand Field Theory**

3-0-3. Prerequisite: Chem. 6141.

Introduction to theory of electronic structure of transition metal compounds and its application to the interpretation of physical and chemical properties of these compounds—especially spectral and magnetic properties.

Text: at the level of Royer, *Ligand Field Theory, An Introduction*.

Chem. 7131. Inorganic Stereochemistry

3-0-3. Prerequisite: Chem. 3112 or consent of school.

A discussion of the structure of inorganic compounds and relationships between structures, bonding and properties of these compounds.

Chem. 7141. Mechanisms of Inorganic Reactions

3-0-3. Prerequisite: Chem. 3112 or consent of school.

Discussion of mechanisms of inorganic reactions based on kinetic and stereochemical studies—the substitution and redox reactions of coordination complexes in solution.

Text: at the level of Basolo and Pearson, *Mechanisms of Inorganic Reactions*.

Chem. 7421. Statistical Thermodynamics

3-0-3. Prerequisite: Chem. 6422 or consent of school.

A study of statistical mechanical ensembles, partition functions and their relationship to thermodynamics, lattice statistics, molecular distribution and correlation functions, the theories of liquids and solutions, phase transitions and cluster theory.

Chem. 7431-2. Principles of Quantum Mechanics

3-0-3. Prerequisite: Chem. 6411 or Phys. 4143

Important concepts of quantum chemistry at the intermediate level including: angular momentum, perturbation theory, electronic structure of molecules and radiation matter interaction. Applications will vary from year to year.

Chem. 7451. Chemical Kinetics

3-0-3. Prerequisite: Chem. 6421-2.

Mechanisms of chemical reactions, cross sections and rate constants. Elastic, inelastic and rearrangement channels are discussed using quantum and semiclassical techniques.

Chem. 7611. Nuclear Spectroscopy

2-0-2. Prerequisite: Chem. 6612 or consent of school.

A study of nuclear levels and of energy absorption and emission by nuclei both by radioactive decay and by nuclear reaction and scattering experiments.

Text: at the level of Siegbahn, *Alpha-, Beta- and Gamma-Spectroscopy*, volumes one and two.

Chem. 8001-2-3. Seminar

1-0-0 each.

Discussion group composed of staff and graduate students.

Chem. 8111-2. Special Topics in Inorganic Chemistry

3-0-3 each. Prerequisite: Chem. 3112.

Topics to be discussed vary from year to year, will include mechanisms of inorganic reactions, Ligand field theory and bonding in inorganic compounds.

Chem. 8211. Special Topics in Analytical Chemistry

2-3-3. Prerequisites: consent of school.

Discussions of specialized areas of analysis: spectrophotometry, polarography, coulometry, chromatography and others. Content of course varies from year to year.

Chem. 8311-2. Special Topics in Organic Chemistry

3-0-3 each. Prerequisite: consent of school.

Topics vary from year to year, will include such subjects as evaluation of synthetic methods and their application to research in organic chemistry.

Chem. 8351-2. Special Topics in Biochemistry

3-0-3 each. Prerequisite: Chem. 4512 or consent of school.

Topics vary from year to year, will include such subjects as proteins, enzyme mechanisms, metabolism and membranes.

Chem. 8411-2. Special Topics in Physical Chemistry

3-0-3 each. Prerequisite: Chem. 3413 or consent of school.

Topics vary from year to year, will include such subjects as photochemistry, solid state, surface chemistry and radiation chemistry.

Chem. 8461. Special Topics in Nuclear Chemistry

3-0-3. Prerequisite: Chem. 6612 or consent of school.

Topics vary from year to year, will include nuclear fission, radiochemical techniques, nuclear

reactions, inbeam nuclear spectroscopy and of line investigations of nuclei far from stability.

Chem. 9000. Doctoral Thesis

CITY PLANNING

See Architecture.

CIVIL ENGINEERING

Civil Engineering

C.E. 1503. Introduction to Civil Engineering
2-3-3. Not offered summer quarter.

What engineering is, what civil engineering is and what civil engineers do. The civil engineering approach to the solution of mankind's problems.

C.E. 2254. Plane Surveying

3-3-4. Prerequisite: E.Gr. 1170.

Use of modern instruments and office procedures in obtaining and analyzing field data for use in engineering planning, design and construction and in land surveying.

C.E. 2502. Civil Engineering Applications of Digital Computers

1-3-2. Prerequisite: Math. 1308.

A study of the application of digital computers to the solution of civil engineering problems. The course is a prerequisite to all junior and senior C.E. courses.

C.E. 3053. Fluid Mechanics I

3-0-3. Prerequisite: E.S.M. 3201.

Elementary mechanics of fluids with emphasis on analysis, fluid kinematics, equations of motion, momentum and energy principles, surface and form resistance.

C.E. 3054. Fluid Mechanics II

3-3-4. Prerequisite: C.E. 3053.

Elementary mechanics of fluids with emphasis on engineering applications. Enclosed conduit flow, open-channel flow, hydraulic machinery, fluid measurements, dynamic similitude.

C.E. 3061. Fluid Mechanics Laboratory

0-3-1. Prerequisite: C.E. 3054.

Experiment, demonstration and analysis of basic fluid phenomena and exercises in laboratory techniques.

C.E. 3216. Structural Analysis I

5-3-6. Prerequisite: E.S.M. 3301.

Determination of internal forces in statically determinate and indeterminate structures including

influence lines with applications to beams, frames and trusses.

C.E. 3254. Advanced Surveying I

3-3-4. Prerequisite: C.E. 2254. Not offered Winter Quarter.

Field astronomy. Precise taping, leveling, triangulation, sub-tense bar, adjustments of level nets and triangulation figures, special problems in land division, introduction to photogrammetry.

C.E. 3309. Materials of Construction

3-3-4. Prerequisite: E.S.M. 3301, Geol. 2100, 2102.

Basic principles of the properties of materials. Physical, chemical and mechanical properties of metals, concrete, timber, masonry and asphalt. The laboratory period is for tests, demonstrations and writing reports.

C.E. 4003. Construction

2-3-3. Prerequisite: I.Sy.E. 4725.

The construction industry, contracts and forms of construction company organization. Financing, equipment, manpower and materials. Time and cost control methods are introduced.

C.E. 4013. Design of Construction Operations

3-0-3. Prerequisite: junior standing.

Modeling and analysis of construction operations at the job site level. Productivity calculations and allocation of construction resources.

C.E. 4053. Applied Hydraulics

3-0-3. Prerequisite: C.E. 3054, 4353.

Analysis and design of hydraulic works and structures. Typical exercises: stability of dams, spillway design, stilling basins, culverts, pipe systems, sediment transport, erosion and erosion control.

C.E. 4103. Sanitary Engineering I

3-0-3. Prerequisite: Math. 2308, Chem. 1102 or consent of school.

Introduction to physical, chemical and biological properties of the aquatic environment with reference to environmental quality. Quality of water for domestic use. Basic principles of aquatic microbiology and chemistry.

C.E. 4113. Sanitary Engineering II

3-0-3. Prerequisite: C.E. 4103. Corequisite: C.E. 3054.

Introduction to waste and water treatment processes. Physical, chemical and biological principles of biological treatment for BOD removal. Coagulation, sedimentation, filtration, nutrient removal and other treatment processes. Engineering of treatment systems.

C.E. 4123. Sanitary Engineering III

2-3-3. Prerequisite: C.E. 4113.

The layout, hydraulic process and operational design of water and waste water systems. Supervised design problems and inspection trips.

C.E. 4133. Engineering Aspects of Environmental Health

3-0-3. Prerequisite: C.E. 4113.

Sanitary engineering in public health administration and control of environmental health problems.

C.E. 4143. Man in His Environment

3-0-3.

Open to students from all fields. On population, resources, wastes and health as related to development of science and technology.

C.E. 4154. Physical Behavior of Soil and Rock

3-3-4. Prerequisite: C.E. 3309, Geol. 2100, 2102.

An introduction to the engineering properties of soil and rock. The origin, composition and structure of soils. The effect of water and control.

C.E. 4163. Soil and Rock Engineering

2-3-3. Prerequisite: C.E. 4154.

Mechanics of soil and rock masses as applied to civil engineering design and construction, footing and pile foundations, retaining walls, bulkheads, fills, embankments, control of landslides.

C.E. 4204. Metal Structural Components

3-3-4. Prerequisite: C.E. 3309, 3216.

Principles of behavior of tension and compression members, beams and connections with application to the design of elementary structures.

C.E. 4213. Structural Analysis II

2-3-3. Prerequisite: C.E. 2502, 3216.

Flexibility and stiffness matrix methods of static structural analysis. Computer programming.

C.E. 4214. Concrete Structural Components

3-3-4. Prerequisite: C.E. 3309, 3216.

Principles of behavior of reinforced concrete beams, columns and slabs with application to the design of elementary structures.

C.E. 4223. Structural Design

2-3-3. Prerequisite: C.E. 4204, 4214, 4154.

Design of structures in metal and concrete with emphasis on buildings and bridges.

C.E. 4233. Design in Timber and Prestressed Concrete

2-3-3. Corequisite: C.E. 4214.

Principles of behavior of timber and of prestressed concrete structural members, application to the design of elementary structures.

C.E. 4253. Elementary Aerial Photogrammetry
2-3-3. Prerequisite: C.E. 3254.

Principles of stereoscopy and stereoscopic instruments. Analytical solutions of altitude, base line, line of flight and parallax. Radial line plotting for planimetric and topographic maps.

C.E. 4273. Advanced Surveying II
2-3-3. Prerequisite: C.E. 3254. Winter quarter.

Errors and adjustments of surveying and photogrammetric instruments, analysis of measurement errors. Mercator and Lambert projections, plane table traversing, special control problems, hydrographic surveying.

C.E. 4283. Advanced Route Surveying
2-3-3. Prerequisite: C.E. 2254.

Horizontal and vertical curves in transportation systems, application of transition curves, earth-work computations, problems involving fixed points and relocations.

C.E. 4304. Transportation Engineering I
3-3-4. Prerequisite: C.E. 3309.

Planning, design and construction of streets and highways. Computer-oriented laboratory problem acquaints student with modern highway design techniques and criteria.

C.E. 4313. Transportation Engineering II
3-0-3. Prerequisite: senior standing.

History and economics of transportation systems, traffic and planning problems and techniques, planning and design of air, rail, highway and water transportation facilities as a system.

C.E. 4353. Hydrology
3-0-3. Prerequisite: C.E. 3054.

Occurrence and movement of water on the earth, hydrologic measurements, elementary meteorology, precipitation, evapotranspiration and runoff, ground water, frequency analysis.

C.E. 4363. Applied Hydrology
3-0-3. Prerequisite: C.E. 3054, 4353. Winter quarter.

Applications of hydrology in the design of hydraulic structures for water supply, irrigation, power, drainage and flood control facilities.

C.E. 4373. Water Resources Development
2-2-3. Prerequisite: C.E. 4353. Spring quarter.

Comprehensive planning for water resources management, identification of needs, problems and issues, alternative creative solutions, economic and financial evaluation, institutional setting and public participation.

C.E. 4383. Groundwater Hydrology
3-0-3. Prerequisite: C.E. 4353, Geol. 2100. Spring quarter.

Occurrence, distribution and movement of water below the surface of the earth, groundwater resources and dependable supply rates from wells, artificial recharge and waste disposal.

C.E. 4774. Application of Microbiology in Sanitary Engineering

3-3-4. Prerequisite: senior standing. Fall quarter.
Microbiology in environmental engineering. Relationship of protozoa, algae, bacteria and viruses to waterborne disease, treatment of wastes and deterioration of aquatic habitats.

C.E. 4801-2-3-4-5-6. Special Topics
Credit hours equal last digit of course number.

C.E. 4811-2-3-23. Special Topics
Credit hours equal last digit of course number.

C.E. 4900. Special Problems
Credit hours to be arranged.

C.E. 6003. Construction Administration
2-3-3. Fall quarter.

Management tools used to carry out administrative aspects of construction project management. Estimating and bid control. Quantity take-off procedures, cost accounting, insurance, bonding, finance and safety.

C.E. 6013. Civil Engineering Management I
2-3-3. Corequisite: I.Sy.E. 6739. Winter quarter.

Scientific methods in the management of construction projects. Techniques such as C.P.M. and P.E.R.T. for planning, scheduling and control of construction projects.

C.E. 6023. Civil Engineering Management II
2-3-3. Prerequisite: C.E. 6013. Corequisite: I.Sy.E. 6734. Spring quarter.

Continuation of C.E. 6013. Additional topics include linear and dynamic programming, queueing models and simulation as applied to construction project management.

C.E. 6053. Flow in Open Channels I
3-0-3. Prerequisite: C.E. 3054, 3061. Fall quarter.

Flow of liquids with free surfaces in natural and artificial channels. Application of energy and momentum principles, analysis of flow resistance, computation of gradually-varied flow profiles.

C.E. 6058. Intermediate Fluid Mechanics I
3-0-3. Prerequisite: C.E. 3054. Fall quarter.

Basic analytical techniques of fluid mechanics. Kinematics and dynamics of fluid flows; Conservation of mass, momentum, and energy; Bernoulli and Navier-Stokes equations; Potential flow.

C.E. 6063. Flow in Open Channels II
3-0-3. Prerequisite: C.E. 3054, 3061. Winter quarter.

Flow of liquids through open channel transitions and controls including weirs, free overfalls, spillways, expansions, contractions, and culverts. Analysis of steady, spatially-varied flow and treatment of unsteady flow in open channels.

C.E. 6068. Intermediate Fluid Mechanics II
3-0-3. Prerequisite: C.E. 6058. Winter quarter.

Low Reynolds number flows. Turbulent flow. Laminar and turbulent boundary layers, boundary layer controls. Lift and drag. Cavitation.

C.E. 6073. Transient Flow in Enclosed Conduits

3-0-3. Prerequisite: C.E. 3054. Spring quarter.
Unsteady flow of compressible and incompressible fluids in conduits, pressure wave propagation, one-dimensional wave equations, method of characteristics, pulsating flow, water hammer, hydraulic machinery, column separation.

C.E. 6078. Engineering Hydrodynamics
3-0-3. Prerequisite: C.E. 6058, Math. 4320. Fall quarter.

Review of complex numbers and conformal transformations. Irrotational flow, stream and potential functions. Hydrodynamic singularities. Free-streamline solutions. Hydraulic flow examples. Approximate methods.

C.E. 6083. Sediment Transport
3-0-3. Prerequisite: C.E. 3054. Spring quarter.

Sediment properties, initiation of sediment motion by flowing water, suspended sediment discharge, bed load discharge, bed form mechanics, hydraulic resistance to flow. Reservoir sedimentation.

C.E. 6088. Coastal Engineering I
3-0-3. Prerequisite: C.E. 6058. Winter quarter.

Hydrodynamic equations of water waves, reflections, transmission and refraction, tides and harbor resonance.

C.E. 6093. Flow Through Porous Media I
3-0-3. Prerequisite: C.E. 6058 or consent of instructor. Winter quarter.

Basic soil properties and Darcy law. Fundamental equations of ground-water flow. Mathematical models and analytical solutions to elementary groundwater flow problems. Basic concepts of unsaturated flow. Approximate methods.

C.E. 6103. Aquatic Chemistry
3-0-3. Prerequisite: C.E. 6139. Spring quarter.

Chemical behavior of natural aquatic systems: lakes, oceans, rivers, estuaries, groundwater, wastewater, treatment systems. Analysis of natural waters using physical chemistry principles.

C.E. 6104. Sanitary Engineering Design I
3-3-4. Prerequisite: C.E. 4103. Spring quarter.

Theory and design of structures for collection, purification, conditioning and distribution of public water supplies.

C.E. 6108. Application of Instrumental Analysis in Sanitary Engineering

2-3-3. Prerequisite: C.E. 6139. Winter quarter.
Theory, design, sensitivity and limitations of environmental sampling instruments. Emphasis on spectrophotometric, electromechanical and gas chromatograph analysis of solid waste, water and wastewater.

C.E. 6113. Industrial Wastes Treatment and Disposal

2-3-3. Prerequisite: C.E. 6144 and C.E. 6149 or consent of school. Spring quarter.

Evaluation of industrial waste problems, character and quantity of wastes produced from various industrial activities, application of engineering principles to treatment and disposal techniques.

C.E. 6114. Sanitary Engineering Design II
3-3-4. Prerequisite: C.E. 4113. Summer quarter.

The theory and design of structures for the collection, treatment and disposal of municipal sewage and industrial wastes, the industrial processes which produce liquid wastes.

C.E. 6118. Solid Waste Technology I
2-3-3. Prerequisite: consent of school. Winter quarter.

An introduction of the fundamentals of solid waste characterization, handling and disposal systems, physical and chemical methods of solid waste analysis.

C.E. 6123. Stream Analysis
3-0-3. Prerequisite: C.E. 3054, 4113. Winter quarter.

Factors affecting deoxygenation and reaeration in streams, evaluation of stream self-purification capacity, design of stream surveys, prediction of the effects of organic loading.

C.E. 6124. Air Pollution Measurements and Control

3-3-4. Prerequisite: consent of school. Fall quarter.

Analysis of air pollution problems of cities and industries, methods of evaluating the problems. Description, design and use of air sampling equipment.

C.E. 6128. Solid Waste Technology II

2-3-3. Prerequisite: C.E. 6118. Spring quarter.

Evaluation of typical solid waste problems, application of fundamental principles to design and management, case studies of operational solid waste systems, new methods, advanced topics.

C.E. 6133. Basic Radiological Health

3-0-3. Prerequisite: consent of school.

Introduction to radiological health and its influence on the general environment and occupational activities, personnel survey and laboratory instrumentation.

C.E. 6138. Applied Limnology

2-3-3. Spring quarter.

Consideration and application of limnological principles as they pertain to evaluating the impact wastewater disposal will have on the biological productivity of inland waters.

C.E. 6139. Applications of Chemistry In Sanitary Engineering

3-3-4. Prerequisite: Chem. 1102, C.E. 4113. Fall quarter.

Review of general and organic chemistry, concepts of biochemistry and physical chemistry, chemistry of water and wastewater processes. Corrosion, coagulation, softening and disinfection.

C.E. 6144. Sanitary Engineering Processes I

3-3-4. Prerequisite: C.E. 3054, 4113. Winter quarter.

Study of selected physical and chemical processes common to water and wastewater treatment systems, i.e. coagulation, flocculation, sedimentation and filtration.

C.E. 6145. Field Methods In Sanitary Engineering

0-15-5. Prerequisite: C.E. 6123, 6138. Summer quarter.

Provides experience in the organization and conduct of sanitary surveys and field studies in stream analysis and applied limnology.

C.E. 6148. Advanced Microbiology of Water and Wastes

2-3-3. Prerequisite: C.E. 4774. Winter quarter.

Microbial growth in water and waste treatment systems, enrichment cultures and their application in process design. Respiratory mechanisms and fermentations in waste treatment and stream pollution.

C.E. 6149. Sanitary Engineering Processes II

3-3-4. Prerequisite: C.E. 6144. Winter quarter.

Study of biological and chemical processes employed in water and waste treatment system. Biological growth kinetics, activated sludge, trickling filters, lagoons and oxidation ponds.

C.E. 6153. Dock, Harbor and Shore Structures

2-3-3. Prerequisite: C.E. 4214. Spring quarter.

Function, design and construction of marine structures such as docks, bulkheads, dry docks, breakwaters, channels and shore protection works.

C.E. 6154. Advanced Soil Mechanics

3-3-4. Prerequisite: C.E. 4163. Winter quarter.

Flow of water through soil and rock, design of drainage systems, earth dams and dam foundations. Elastic and plastic equilibrium applied to problems of slope stability.

C.E. 6159. Rock Mechanics

3-3-4. Prerequisite: C.E. 4163. Spring quarter.

Mechanics of rock masses and influence of geologic features on their engineering properties. Discussion of relevant tests for determination of both in situ and laboratory properties of rocks.

C.E. 6163. Physical and Physiochemical Properties of Soils

3-0-3. Prerequisite: C.E. 4154. Fall quarter.

Formation of soils, physical chemistry of soil minerals and soil water, consolidation, swell, shrinkage, shear strength and related phenomena, geology of soil deposits.

C.E. 6164. Advanced Foundation Engineering

3-3-4. Prerequisite: C.E. 4163. Spring and summer quarters.

Analysis and design of foundations, bearing capacity and settlement theory. Analysis of pile and continuous foundations, theories of earth pressure, design of earth-retaining structures.

C.E. 6172. Soil Testing

1-3-2. Prerequisite: C.E. 6194. Winter quarter.

Theory of physical testing of soils for engineering design and research, laboratory exercises in consolidation and shear testing, illustrations of test procedure effects on character of data.

C.E. 6173. Terrain Evaluation and Applications

2-3-3. Prerequisite: C.E. 4163. Fall quarter.

Structure of soil and rock formations and their reflection in the terrain. Analysis of terrain features by aerial photographs and other forms of remote sensing.

C.E. 6183. Soil Construction

2-3-3. Corequisite: C.E. 4154. Fall quarter.

The migration of soil moisture, frost action, compaction, soil stabilization, evaluation of subgrades and bases for pavements.

C.E. 6193. Dynamics of Massive Media

2-3-3. Prerequisite: C.E. 6194. Spring quarter.

Introduction to dynamics of massive media

with applications to analysis of complex engineering dynamics problems. Dynamic properties of soil and rock.

C.E. 6194. Theoretical and Applied Soil Mechanics I

4-0-4. Corequisite: C.E. 6163. Fall quarter.

Theories of elastic equilibrium of soil masses, application to analysis of complex soil engineering problems such as stresses and settlements of soil and pavement.

C.E. 6199. Theoretical and Applied Soil Mechanics II

4-0-4. Prerequisite: C.E. 6194. Winter quarter.

Theories of plastic equilibrium of soil masses, application to analysis of complex soil engineering problems. Pressures on earth retaining structures, anchored bulkheads, laterally-loaded piles.

C.E. 6203. Structural Planning

3-0-3. Prerequisite: C.E. 3216. Spring and summer quarters.

Introduction to planning aspects of structural design, economic proportions, erection procedures, comparison of determinate and indeterminate structures, stress control, normal and hybrid behavior.

C.E. 6204. Reinforced Concrete Structures I

4-0-4. Prerequisite: C.E. 4214. Fall quarter.

Review of working stress methods, analysis and design procedures based on ultimate load capacity, effects of creep, shrinkage and temperature, torsional stresses and reinforcing, deflections.

C.E. 6209. Reinforced Concrete Structures II

4-0-4. Prerequisite: C.E. 6204. Winter quarter.

Principles and practice of pre-stressed concrete, systems and techniques for applying prestress, analysis and design of determinate and indeterminate pre-stressed concrete structures, ultimate strength behavior.

C.E. 6213. Experimental Analysis I

3-0-3. Winter quarter.

Data acquisition from models. Stress analysis through strain measurements. Transducers, their circuitry and related indicating and recording equipment. Motion measurement, equivalent circuits.

C.E. 6214. Indeterminate Structural Theory I

4-0-4. Prerequisite: C.E. 3216. Fall quarter.

Study of principles and fundamental theorems of structural analysis with applications to indeterminate structures: beams, frames and trusses.

C.E. 6219. Matrix Methods of Structural Dynamics

4-0-4. Prerequisite: C.E. 6229, C.E. 6248. Winter quarter.

Linear and nonlinear dynamic matrix analysis of multi-degree of freedom structural systems. Substructuring techniques. Analysis and design for wind and earthquake. Computer programming.

C.E. 6229. Principles of Matrix Structural Analysis

4-0-4. Prerequisite: C.E. 3216. Fall quarter.

Matrix formulation of the governing equations of framed structures, linear elastic behavior, physical and geometrical nonlinearities, force and displacement methods, nonlinear analysis.

C.E. 6234. Advanced Structural Mechanics

4-0-4. Prerequisite: Math. 2309. Winter quarter.

Study of advanced topics from mechanics of materials with application to civil engineering structures. Typical topics: generalized stress and strain, failure theories, torsion, shear flow, buckling, fatigue.

C.E. 6238. Finite Element Method of Structural Analysis

3-0-3. Prerequisite: C.E. 6229. Spring quarter.

Introduction to finite element method, matrix formulation. Plates in plane stress, plane strain and bending. Three-dimensional solids and shells. Static and dynamic, linear and nonlinear analysis.

C.E. 6244. Plastic Design In Steel

4-0-4. Prerequisite: C.E. 4204. Spring quarter.

Analysis and design procedures based on ultimate load capacity are applied to steel beams, frames and their connections.

C.E. 6248. Structural Dynamics

3-0-3. Prerequisite: consent of school. Fall quarter.

Vibration and dynamic response of simple linear and nonlinear structures to periodic and general disturbing forces. Response analysis of multi-degree of freedom systems. Wind and earthquake effects.

C.E. 6249. Reinforced Concrete Structures III

4-0-4. Prerequisite: C.E. 6209, Math. 2309.

Spring quarter.

Analysis and design of slab and thin-shell structures, additional applications of prestressing, yield-line theory, shells of revolution, cylindrical shells, folded plates, hyperbolic paraboloids, pre-stressed tanks.

C.E. 6273. Legal Principles of Land Surveying
2-3-3. Prerequisite: C.E. 3254. Winter quarter, alternate years.

History and development of legal principles controlling boundary location of real property. Writing, interpreting and locating of deed descriptions.

C.E. 6303. Pavement Design
3-0-3. Prerequisite: C.E. 4304, 4154. Winter quarter.

Theory of flexible and rigid pavement behavior, stress conditions and deflection, climate, pavement design methods and evaluation of pavement performance.

C.E. 6308. Concrete Technology
2-3-3. Prerequisite: C.E. 3309, 4214. Winter quarter.

Design theories for concrete mixes, mixes for specific conditions of workability, density, strength, admixtures and air entrainment. Preparation and testing of concrete mixtures, minor research in concrete.

C.E. 6313. Airport Planning and Design
2-3-3. Prerequisite: C.E. 4304. Fall quarter.

Airport site selection, runway length and orientation, traffic control, drainage and lighting, long-range planning, government responsibility for air transportation.

C.E. 6318. Asphalt Technology
2-3-3. Prerequisite: C.E. 4313, 4154. Spring quarter.

Theory of asphalt mix design. Preparation of asphaltic mixes for stability, durability, economy. Use of various materials and grades of asphalt in bituminous concrete pavements.

C.E. 6323. Transportation Administration
2-3-3. Fall quarter.

Advanced study of national transportation policies, financial problems, administrative procedures relating to development of transportation facilities.

C.E. 6328. Mass Transit Planning
3-0-3. Prerequisite: consent of school. Spring quarter.

Characteristics and costs of present and innovative mass transit systems. Roles of engineer, planner and others in estimating transit usage and choosing optimal plan.

C.E. 6333. Traffic Engineering
2-3-3. Prerequisite: C.E. 4304. Fall quarter.

Characteristics of drivers and vehicles, traffic studies, capacity, signal systems, engineering solution of traffic movement problems. Supervised traffic engineering studies.

C.E. 6338. Advanced Traffic Operations
2-3-3. Prerequisite: C.E. 6333. Winter quarter.

Application of traffic control devices to improve capacity, safety of urban street systems. Emphasis on computer control of signal systems, application of computer simulation models.

C.E. 6343. Design of Highways and Transit Facilities

2-3-3. Prerequisite: C.E. 6333. Spring quarter.
Geometric configurations of streets, expressways, busways, railways and their terminals to meet characteristics of vehicle performance and operator limitations.

C.E. 6344. Urban Transportation Planning
3-3-4. Prerequisite: C.E. 6333. Winter quarter.
Planning of urban transportation facilities, mathematical models for prediction of traffic flow, assignment, interrelationship of land use and trips, parking and the transportation problem.

C.E. 6348. Theory of Traffic Flow
2-3-3. Prerequisite: I.Sy.E. 6739, C.E. 6343. Summer quarter.

Traffic flow phenomena, description of traffic arrival, merging movements, shock waves by mathematical models, simulation of traffic flow processes and applications.

C.E. 6353. Economic and Financial Aspects of Public Works Planning
3-0-3. Fall quarter.

Discounting techniques for public works planning. Microeconomics in project formulation. Applications from welfare economics, capital formation theory, input-output analysis.

C.E. 6363. Economics of Water Resources Development

2-2-3. Prerequisite: C.E. 6353. Winter quarter.
Principles of resource allocation, benefit-cost analysis, water-resources project formulation, justification, allocation of joint costs in multipurpose developments.

C.E. 6373. Flood Management
3-0-3.

Hydrology and hydraulics of flood management measures. Analysis of flood control and flood damage abatement: levees, floodways, channel improvements, reservoirs.

C.E. 6378. Physical Hydrology
3-0-3. Prerequisite: C.E. 4353 or consent of instructor. Fall quarter.

Study of physical processes governing occurrence, movement and distribution of water including atmospheric transport processes and circulation, physical composition of atmosphere, oceans and lakes, precipitation, evaporation,

transpiration, snowmelt, infiltration, groundwater flow and catchment morphology.

C.E. 6383. Statistical Hydrology
3-0-3. Prerequisite: Probability theory or consent of instructor. Fall quarter.

Probability distributions applicable to hydrologic events; analysis of extreme events, floods and droughts, regression and correlation analysis of hydrologic variables, application of Markov chains and point processes to the sequences of hydrologic events.

C.E. 6388. Watershed Models I
2-3-3. Prerequisite: C.E. 4353 or consent of instructor. Winter quarter.

Development of concepts used in deterministic watershed simulation models including surface runoff, overload flow, streamflow, flood routing, reservoir routing. Linear catchment models. Data preparation techniques for watershed models.

C.E. 6393. Urban Hydrology
2-3-3. Prerequisite: C.E. 4353 or consent of instructor. Summer quarter.

Effects of urbanization on storm runoff, sedimentation, water quality and water supply. Modeling of urban runoff. Urban watershed in planning and design. Legal, institutional, and economic framework.

C.E. 6399. Water Resources Systems I
3-0-3. Prerequisite: I.Sy.E. 6734 or equivalent, or consent of instructor. Spring quarter.

Review and application of operations research methodologies including classical optimization, linear programming, non-linear programming and dynamic programming, to planning and design of water resource systems.

C.E. 6703. Urban Sanitary Facilities
2-3-3. Fall quarter. No credit for civil or sanitary engineering students.

Basic information for city planner on engineering aspects of water supply, sewage, storm drainage, waste collection and disposal systems, public health administration and environmental sanitation.

C.E. 6704. Urban Transportation Facilities and Policies
3-3-4. Fall quarter. No credit for civil engineering students.

Interrelated planning of urban transportation facilities. The engineering of vehicular thoroughfares including standards, highway capacity estimates, traffic regulation surveys and parking studies.

C.E. 6751-2. Complex Systems Design
2-4-3 each. Prerequisite: graduate standing.

Permits students from all schools to meet, form an interdisciplinary team and carry out a preliminary design of a significant, complex system.

C.E. 6772. Advanced Computer Interfacing and Design

2-3-3. Prerequisite: N.E. 6770. Spring quarter.
A study of system design using MSI and LSI chips, and programmable digital devices as system modules. Subjects include Boolean optimization and register transfer design techniques.

C.E. 6773. Computer Control of Real-Time Systems

3-3-4. Prerequisites: N.E. 6770, E.E. 4077 or equivalent. Summer quarter.

A study of concepts common to all computer controlled real-time systems. Subjects include evolution of time sets, vectored interrupts and statistical alarm conditions.

C.E. 6775. Advanced Engineering Programming Methods

3-3-4. Prerequisite: C.E. 2502 or equivalent. Summer quarter.

Advanced engineering programming concepts and their implementation on large scale digital computers. Dynamic data, dynamic programs, engineering data management, engineering problem oriented language development and ICES.

C.E. 7000. Master's Thesis
Credit hours to be arranged.

C.E. 7999. Doctoral Examinations Preparation
Credit hours to be arranged.

For students preparing for doctoral qualifying or language examinations or both.

C.E. 8001. Seminar in Sanitary Engineering
0-2-1. Prerequisite: consent of school.

Developments in sanitary engineering science and technology, current research and special topics related to environmental quality assessment and control.

C.E. 8011-21. Seminar in Water Resources Problems I and II

0-2-1 each. Fall and winter quarters.

Seminar discussions of current environmental management issues. Guest participants will include advocates of different interest groups.

C.E. 8031. Seminar in Soil and Rock Mechanics

0-2-1. Corequisite: C.E. 6154 and consent of the school. Winter quarter.

Case histories of design and construction problems involving soil and rock mechanics, in-

cluding excavations, drainage, dams, retaining structures and slope stability.

C.E. 8041. Seminar in Foundation Engineering

1-0-1. Prerequisite: C.E. 6154. Corequisite: C.E. 6164. Spring quarter.

Case histories of design, construction and performance of foundations. Special topics such as machine foundations, foundations in seismic regions.

C.E. 8051. Seminar in Transportation Engineering

1-0-1. Prerequisite: consent of school. Winter quarter.

Developments in the design and planning of traffic engineering and transportation systems, impact of current literature and technology on the field.

C.E. 8061. Construction Seminar

0-2-1. Corequisite: C.E. 6003.

Engineered construction. Whenever possible, guest speakers from the construction industry. Graduate students will present results of required special research projects and thesis research.

C.E. 8101-2-3-4-5. Special Topics

Credit hours equal last digit of course number.

C.E. 8113-4-23. Special Topics

Credit hours equal last digit of course number.

C.E. 8500-1-2. Special Problems

Credit hours to be arranged.

C.E. 8756. Master's Special Research Problem

Credit hours to be arranged.

Six to 12 hours of master's research problem to be scheduled by master's students not writing thesis during two or more successive quarters.

C.E. 8999. Doctoral Thesis Preparation

Credit hours to be arranged.

For student in preliminary stages of formulating doctoral research program but who has not obtained formal approval of thesis topic.

C.E. 9000. Doctoral Thesis

Engineering Graphics

E.Gr. 1170. Introduction to Visual Communication and Engineering Design I

2-3-3.

Theory and application of the design process, assigned design project and report. Elements of

projection theory that enhance ability to communicate graphically.

E.Gr. 1171. Introduction to Visual Communication and Engineering Design II

2-3-3. Prerequisite: E.Gr. 1170.

Considers environmental, human, material and socioeconomic factors. Team project reports. Graphical analysis of empirical equations, calculus, nomography.

ECONOMICS

See Management.

ELECTRICAL ENGINEERING

E.E. 1001. Introduction to Electrical Engineering

1-0-1. Enrollment limited to freshmen.

An introduction to electrical engineering, both at Georgia Tech and in industry. Lectures, discussion and outside work provide insight to the exciting directions the profession is taking.

E.E. 1010. Computer Programming and Graphics

2-3-3.

Computer programming and graphics using a problem solving approach. Programs are written in FORTRAN IV for the main campus computer (CDC Cyber 74) and a CALCOMP PLOTTER.

Text: Cress, Dirksen and Graham, *FORTRAN IV with WATFOR and WATFIV*.

E.E. 1011. Electrical Engineering Fundamentals

2-3-3.

Survey of the diverse areas within electrical engineering. Basic engineering concepts developed and applied quantitatively to representative engineering problems.

E.E. 1750. Introduction to Bioengineering

3-0-3.

An introduction to aspects of science and technology pertinent to bioengineering, with emphasis on ongoing activity at Georgia Tech.

E.E. 1900-1-2-3. Special Problems

Credit to be arranged. Normally taken by freshmen.

Special engineering problems are assigned according to each student's needs, interests and capabilities.

E.E. 2900-1-2-3. Special Problems

Credit to be arranged. Normally taken by sophomores.

Special engineering problems are assigned according to each student's needs, interests and capabilities.

E.E. 3015. Mechanical Plant of Buildings

3-0-3. Prerequisite: either E.E. 3200, 3700 or 3725.

Electrical power distribution systems for buildings and plants. Study of National Electrical Code. Lighting design considering sources, luminaires and reflectances.

Text: McGuinness, Stein, Gay and Fawcett, *Electrical Equipment for Buildings*.

E.E. 3032. Computer Engineering I

3-0-3. Prerequisite: E.E. 1010 or equivalent.

Machine language, machine organization and design concepts of digital computers. Loaders, assemblers, subroutines, recursion and reentrant programs. Microprogram control. Input, output and storage devices.

E.E. 3033. Computer Engineering II

3-3-4. Prerequisite: E.E. 3360.

Register transfer level logic design using microoperations. Design computing structures including sequences for instruction fetch, addition, multiplication, division, shifting, logical operations, timing and control. Discussion of bus structures, interrupts and input/output. Design projects based on CDL.

E.E. 3034. Computer Engineering III

3-0-3. Prerequisite: E.E. 3360.

A study of computational algorithms for computers and their implementation via hardware and software. Topics include fixed point add/subtract/multiply/divide, binary coded decimal operations, floating point operations and special functions. Several design projects are assigned for special credit.

E.E. 3036. Computational Methods for Simulation

3-0-3. Prerequisite: Math. 2309 or 3308.

A study of numerical algorithms for solving complex electrical engineering problems using digital computers. Theoretical approaches and practical algorithms are discussed.

E.E. 3042. Electrical Measurements

3-3-4. Prerequisite: E.E. 3270, 3360, 3421.

A study of measurements of electrical quantities using electromechanical and electronic, analog and digital methods, consideration of recording, indication and processing of measurement data.

Text: Cooper, *Electronic Instrumentation and Measurement Techniques*.

E.E. 3200. Elements of Electrical Engineering

3-0-3. Prerequisite: Phys. 2122, Math. 2307.

Introduction to basic concepts of circuit elements, circuit models and techniques for circuit analysis.

Text: Su, *Fundamentals of Circuits, Electronics, and Signal Analysis*.

E.E. 3210. Circuits and Systems

3-0-3. Prerequisite: E.E. 3250, Math. 3308.

System analysis in the time and frequency domains. Convolution, Fourier series and Fourier transform with applications.

E.E. 3215. Signals and Systems

3-0-3. Prerequisite: E.E. 3210.

An introduction to the fundamentals of signal representation, system characterization and signal processing with applications to communication, control and instrumentation.

E.E. 3220. Circuits and Systems

3-0-3. Prerequisite: E.E. 3210. Corequisite: E.E. 3215.

Representation of continuous and discrete dynamic systems utilizing transform and state variable techniques. Properties of closed loop systems. Stability analysis.

E.E. 3250. Elements of Electrical Engineering

3-0-3. Prerequisite: E.E. 3200.

Development of concepts in modeling terminal characteristics of electronic devices and techniques for analyzing electronic circuits.

Texts: Su, *Fundamentals of Circuits, Electronics and Signal Analysis* and Millman and Halkias, *Integrated Electronics*.

E.E. 3260. Engineering Electronics

3-0-3. Prerequisite: E.E. 3250.

Development of techniques necessary for the analysis of active linear electronic circuits.

Text: Millman, *Microelectronics*.

E.E. 3270. Nonlinear Devices and Circuits

3-0-3. Prerequisites: E.E. 3210, E.E. 3260.

Presentation of concepts important in the analysis and design of systems utilizing linear and nonlinear devices and circuits.

Texts: Millman, *Microelectronics*.

E.E. 3300. Electromagnetics

3-0-3. Prerequisite: Math. 3308, Phys. 2122 and E.E. 3250.

A study of the Maxwell equations and the Helmholtz wave equations. Electromagnetic theory of simple media. Electrostatics, magnetostatics and electromagnetostatics.

Text: Paris and Hurd, *Basic Electromagnetic Theory*.

E.E. 3310. Electromagnetics

3-0-3. Prerequisite: E.E. 3300, 3210.

Electromagnetic energy and momentum. Virtual work and forces. Reflection and refraction of plane waves in dissipative media. Traveling waves and standing waves.

Text: Paris and Hurd, *Basic Electromagnetic Theory*.

E.E. 3320. Electromagnetics

3-0-3. Prerequisite: E.E. 3310.

Transmission lines and waveguides. Wire and aperture antennas. Arrays. Quasistatics.

Text: Paris and Hurd, *Basic Electromagnetic Theory*.

E.E. 3330. Electromechanical Systems and Energy Conversion

3-0-3. Prerequisite: E.E. 3310, 3210.

Fundamentals of electromechanical energy conversion, electromechanical devices and systems. Energy state functions, force energy relationships, basic transducers, introduction to A.C. and D.C. machines.

Text: Fitzgerald, Kingsley, and Kusko, *Electric Machinery*.

E.E. 3340. Random Signals and Noise

3-0-3. Prerequisite: E.E. 3215.

Study of probability, random variables and random processes for applications in electrical engineering.

E.E. 3360. Digital Hardware

3-0-3. Corequisite: E.E. 3411.

A study of gates, flip-flops, counters, registers, memory devices and integrated circuits. Consideration of the architecture of computers and digital systems.

Text: Greenfield, *Practical Digital Design Using IC's*.

E.E. 3400. Instrumentation Laboratory

1-3-2. Prerequisite: E.E. 3200.

Introduction to instrumentation equipment and techniques. Basic laboratory techniques and practice. Operation of oscilloscopes and meters. Measurement of parameters of electrical engineering components and devices.

E.E. 3411. Junior Electrical Engineering Laboratory I

0-3-1. Corequisite: E.E. 3360.

Exercises in combinational and sequential design and hardware implementation utilizing TTL gates, flip flops, multiplexers and counters.

E.E. 3421. Junior Electrical Engineering Laboratory II

0-3-1. Prerequisite: E.E. 3400. Corequisite: E.E. 3270.

Experiments in linear circuits and electronics with emphasis on the relationship between circuit models and their physical realization.

E.E. 3431. Junior Electrical Engineering Laboratory III

0-3-1. Prerequisites: E.E. 3270, 3400.

Presentation of topics for experimentation in circuits and electronics which illustrate the operation and application of integrated circuits.

Text: Connelly, *Experiments with Integrated Circuits and Systems*.

E.E. 3700. Elements of Electric Circuits and Instruments

3-0-3. Prerequisite: Phys. 2122 and Math. 2307.

For non-electrical engineering students. Elements of electric and electronic circuits principally from a terminal characteristics viewpoint.

Text: Smith, *Electronics: Circuits and Devices*.

E.E. 3710. Introduction to Electronic Systems

3-0-3. Prerequisite: E.E. 3700.

For non-electrical engineering students. Fundamental active circuits are reviewed and basic linear and digital building blocks developed. Modular approach to system design is stressed through the use of integrated circuits.

Text: Smith, *Electronics: Circuits and Devices*.

E.E. 3725. Electric Circuits and Fields

2-3-3. Prerequisite: Phys. 2122 and Math 2308.

For non-electrical engineering students. Study of electric circuit elements and the steady state and transient response of circuits to periodic and step inputs.

Text: Fitzgerald, Higginbotham, Grabel, *Basic Electrical Engineering*.

E.E. 3726. Elementary Electronics

2-3-3. Prerequisite: E.E. 3725.

For non-electrical engineering students. An introduction to electronic and semiconductor devices and a study of circuits containing such elements. Both linear and digital systems are considered. Laboratory experiments.

Text: Fitzgerald, Higginbotham, Grabel, *Basic Electrical Engineering*.

E.E. 3727. Electric Power Conversion

2-3-3. Prerequisite: E.E. 3725.

For non-electrical engineering students. A study of energy conversion principles and devices such as motors, generators, transformers and rectifiers. Lecture and laboratory periods.

Text: Fitzgerald, Higginbotham, Grabel, *Basic Electrical Engineering*.

E.E. 3740. Electrical Instrumentation Laboratory

0-3-1. Corequisite: E.E. 3700.

For non-electrical engineering students. An introduction to the operation and application of basic electrical instruments. Coordinated descriptive lectures and laboratory exercises.

E.E. 3741. Electronic Systems Laboratory

0-3-1. Prerequisite: E.E. 3740, corequisite: E.E. 3710.

For non-electrical engineering students. An introduction to linear and digital electronic systems with the aid of integrated circuit modules.

E.E. 3900-1-2-3. Special Problems

Credit to be arranged. Normally taken by juniors.

Special engineering problems are assigned according to each student's needs, interests and capabilities.

E.E. 4011. Analog Filter Design

3-0-3. Prerequisite: E.E. 3220

An introduction to the theory, design techniques and applications of analog passive and active filters.

Text: Johnson, *Introduction to Filter Theory*.

E.E. 4012. Electric Energy Conversion

3-3-4. Prerequisite: E.E. 3330.

Principles of rotating A.C. and D.C. machines. Analysis techniques and application studies of individual and interconnected devices. Coordinated laboratory exercises.

Text: Matsch, *Electromagnetic and Electromechanical Machines*.

E.E. 4015. Principles of Feedback Control

3-3-4. Prerequisite: E.E. 3220.

A study of automatic control systems. Basic control principles, system modeling and analysis techniques. Coordinated laboratory exercises.

E.E. 4017. Pulse Circuits

3-0-3. Prerequisite: E.E. 3270.

Systems analysis/design for processing analog and digital data, generation and synchronization of sweeps, switching considerations of MOSFET multivibrators, active-element memories, D.-A. and A.-D. converters.

Text: Taub and Schilling, *Digital Integrated Electronics*.

E.E. 4019. Power System Analysis

3-0-3. Prerequisite: E.E. 3200 or consent of school.

A study of power systems, power system components and techniques of analysis.

E.E. 4020. Solid-state Electronics

3-3-4. Prerequisite: E.E. 4350.

Study of underlying physics and resultant terminal properties of solid-state devices such as transistors, charge coupled devices and microwave to optical devices.

E.E. 4021. Electromagnetic Properties of Solids

3-3-4. Prerequisite: E.E. 4350.

Properties of dielectric and magnetic materials including piezoelectricity, superconductivity, magnetic domain dynamics and ferromagnetic resonance. Applications as transducers, memories, logic elements and microwave devices.

E.E. 4022. Industrial Electronics

3-3-4. Prerequisite: E.E. 3210, 3270, 3360.

A study of analog and digital process control including signal conditioning, transducers, actuators and control elements.

Text: Johnson, *Process Control Instrumentation Technology*.

E.E. 4023. Integrated Circuits and Systems

3-0-3. Prerequisite: E.E. 3270.

A study of integrated circuit technology available today. The merits and drawbacks to electronic applications offered by circuit configurations available in digital and linear ICs.

Text: Grinich and Jackson, *Introduction to Integrated Circuits*.

E.E. 4024. Speech Analysis, Synthesis and Compression

3-0-3. Prerequisite: E.E. 3210 or consent of school.

Modern speech analysis and synthesis techniques as applied to the communication problem of speech synthesis. Classical phonology, vocoders, vocal track analogs, spectral analysis of speech.

Text: Flanagan, *Theory of Speech Analysis, Synthesis and Perception*.

E.E. 4025. Information Theory

3-0-3. Prerequisite: E.E. 3340 or equivalent.

Definitions and applications of the measure of information, redundancy, channel, channel capacity and mutual information and Shannon's coding theorems are presented with emphasis on communication problems.

Text: Abramson, *Information Theory and Coding*.

E.E. 4026. Audio Engineering

3-0-3. Prerequisite: E.E. 3270, 3310.

An introduction to the application of the tools of electrical engineering to the detection, measurement, processing, recording and reproduction of audio frequency signals. Basic principles of sound. Microphones. Loudspeakers. Power amplifiers. Disk phonograph systems. Magnetic tape systems. Broadcast audio. Audio signal processing. Acoustical instrumentation.

E.E. 4027. Computer Graphic Design

3-0-3. Prerequisite: E.E. 1010 or equivalent and junior standing.

Principles of computer-aided design (CAD), with emphasis on interactive graphics. Engineering applications and introduction to hardware and programming for interactive computing.

E.E. 4028. Communication Engineering

3-3-4. Prerequisite: E.E. 3210, 3270.

Circuit design for communication systems operating below one gigahertz. Impedance matching, introduction to random noise, small signal and power amplifiers, primarily for analog system applications.

E.E. 4030. Communication Engineering

3-3-4. Prerequisite: E.E. 3210, 3270.

Theory and practice in the design of radio and television receivers. Also a study of signal propagation, radio frequency interference, frequency allocation and fundamental antennas.

E.E. 4032. Communication Circuits

3-3-4. Prerequisite: E.E. 3210.

A study of two-port communication circuits by means of methods of modern network synthesis.

Text: Temps and LaPatra, *Circuit Synthesis and Design*.

E.E. 4034. High-frequency Measurements

3-0-3. Prerequisite: E.E. 3320.

High-frequency measurements emphasizing the characteristics of standard laboratory equipment together with the techniques of high-frequency measurements. Includes system design and state-of-the-art measurements.

Text: Thomas and Clarke, *Handbook of Electronic Instruments and Measurement Techniques*.

E.E. 4035. High Frequency Amplifier Design

3-0-3. Prerequisite: E.E. 3270, E.E. 3320.

An introduction to the techniques used in the analysis and design of high frequency amplifiers with emphasis placed on design.

Text: Carson, *High Frequency Amplifiers*.

E.E. 4036. Ultra-high-frequency Techniques

3-3-4. Prerequisite: E.E. 3320.

Introduction to waveguides, cavities, klystrons, magnetrons, traveling wave tubes, impatt diodes, ferrite gyrators and circulators. Associated laboratory emphasizes microwave measurements.

Text: Collin, *Foundations for Microwave Engineering*.

E.E. 4037. Antennas

3-3-4. Prerequisite: E.E. 3320.

Introduction to linear antennas, linear arrays and aperture antennas. Far field pattern calculation

and measurement are presented. Students design and construct antennas in associated laboratory.

Text: Kraus, *Antennas*.

E.E. 4039. Electrical Sensors and Transducers

3-0-3. Prerequisite: senior standing or consent of school.

Survey of how electrical sensors function and their system applications. Classical, state-of-the-art and advanced sensors and systems are examined for design purposes.

E.E. 4041. Illumination Engineering

3-0-3. Prerequisite: Phys. 2123, E.E. 3310.

An introduction to interior and exterior lighting design. Basic topics considered are light, sight, color, photometry, illumination, luminaires and sources.

E.E. 4042. Electrical Design

3-3-4. Prerequisite: E.E. 3220 or consent of school.

Team-oriented electrical and electronic system design problems of various types. Topics often specified in advance and often related to national student engineering competitions.

E.E. 4043. Linear Graph Theory

3-0-3. Prerequisite: E.E. 3210.

Comprehensive and unified study of oriented and nonoriented graphs for use in network topology, analysis and synthesis, signal flow theory and communication networks.

E.E. 4045. Power System Protection

3-0-3. Prerequisite: E.E. 4019.

An introduction to fundamental concepts in the protection of electric power system apparatus.

Text: Blackburn, *Applied Protective Relaying*.

E.E. 4046. Power System Engineering

3-0-3. Prerequisite: E.E. 4019.

Modeling of power system elements and components, elements of steady state operation and power system protection.

E.E. 4047. Power Electronics

3-0-3. Prerequisite: E.E. 3270.

An introduction to power semiconductor devices and to the electronic circuits incorporating these devices that can be used in the amplification, generation and control of electrical energy.

E.E. 4050. Optical Engineering

3-0-3. Prerequisite: E.E. 3320 or consent of school.

Introduction to optics and optical systems as applied to modern engineering problems. Image formation, holography, optical data processing,

optical memories, specification of optical systems, fiber optics.

Text: Meyer-Arendt, *Classical and Modern Optics*.

E.E. 4051. Fiber Optics

3-0-3. Prerequisite: E.E. 3310 or consent of school.

Exploration of state-of-the-art material related to the fabrication, measurement and use of optical fibers. Development of the theory of dielectric waveguides.

Text: Gloge, *Fiber Optic Technology* and class notes.

E.E. 4061. Communication Systems

3-0-3. Prerequisite: E.E. 3340 or equivalent, E.E. 3215.

Definitions, basic concepts and applications of analog and digital modulation techniques are considered. Modulators for generating various signals and demodulators for information recovery are studied.

E.E. 4062. Communication Systems Laboratory

0-3-1. Prerequisites: E.E. 3340 or equivalent, E.E. 3400. Corequisite: E.E. 4061.

Experiments in signal processing and communication systems.

E.E. 4075. Microcomputer-Based Design

3-3-4. Prerequisites: E.E. 3032 and E.E. 3360 or equivalent.

Development of the ability to define and design "smart" microcomputer-based instruments will be emphasized.

Text: Peatman, *Microcomputer-Based Design*.

E.E. 4076. Special Purpose Digital Systems Design

3-3-4. Prerequisites: E.E. 3360 and E.E. 4075.

Digital circuitry which augments the capabilities of a microcomputer will be discussed. Designing for maintainability is emphasized.

Text: Peatman, *Digital Hardware Design*.

E.E. 4077. Interfacing Small Computers

3-3-4. Prerequisite: E.E. 3360.

The input-output structure and programming of small computers is studied together with the characteristics of a variety of peripheral devices. Emphasis is placed on design problem work.

Text: Data General and Georgia Tech, *Interfacing Small Computers*.

E.E. 4078. Digital Signal Processing

3-0-3. Prerequisite: E.E. 3215.

An introduction to the theory and application of processing discrete data. Special attention will

be paid to the design and implementation of both FIR and IIR digital filters.

E.E. 4079. Introduction to Automaton Theory

3-0-3. Normally taken by seniors.

A study of the properties of linear sequential systems in relation to their applications in various digital tasks.

E.E. 4080. Introduction to Sequential Systems

3-0-3. Prerequisite: E.E. 3360 or equivalent.

A study of procedures for synthesis of synchronous and asynchronous sequential systems.

Text: Torng, *Switching Circuits Theory and Logic Design*.

E.E. 4081. Introduction to Bioelectronics

3-0-3. Prerequisite: E.E. 3270 or consent of school.

An introduction to the study of the electrical phenomena of biological systems. The measurement and control of biological systems.

E.E. 4082. Linear System Theory

3-0-3. Prerequisite: E.E. 3220.

Linear system theory with emphasis on transform and state-variable methods. Applications to both continuous and discrete systems.

E.E. 4083. Computer Simulation of Systems

3-3-4. Prerequisite: E.E. 3220.

Simulation methods by analog, digital and hybrid computers. Digital simulation languages. State variable approach to system simulation. Simulation of complicated systems. Examples and class problems.

E.E. 4084. Transistor Circuit Analysis

3-0-3. Prerequisite: E.E. 3270. Corequisite: E.E. 4085.

Analysis and design of linear electronic circuits. Single stage amplifiers, multistage amplifiers, tuned amplifiers with emphasis on design techniques.

Text: Pierce and Paulus, *Applied Electronics*.

E.E. 4085. Electronic Design Laboratory

0-3-1. Corequisite: E.E. 4084.

Practical design problems which emphasize creativity and imagination are posed and their solutions are individually implemented in the laboratory.

E.E. 4086. Operational Amplifier Design

3-3-4. Prerequisite: E.E. 3270.

Theory and applications of operational amplifiers as they are currently utilized in today's electronic systems to produce both linear and nonlinear functional operations.

Text: Wait, Huelsman and Korn, *Introduction to Operational Amplifier Theory and Applications*.

E.E. 4087. Biomedical Instrumentation

3-3-4. Prerequisite: E.E. 3220 or 3700 or Phys. 2122.

Instrumentation used in the hospital and clinic from a systems viewpoint. Includes a review of pertinent physiological and electrophysiological concepts.

Text: Webster, *Medical Instrumentation Application and Design*.

E.E. 4088. Microcomputer-Based Design II

3-0-3. Prerequisite: E.E. 4075.

A variety of hardware and software topics of importance for the design of "smart" instruments will be explored.

Text: Peatman, *Microcomputer-Based Design*.

E.E. 4090. E.E. Senior Seminar

1-0-1. Prerequisite: E.E. junior standing.

Bridge between an undergraduate electrical engineering education and a postgraduate career. Talk followed by a question and answer period with various authorities.

E.E. 4095. Electrical Transients in Power Systems

3-0-3. Prerequisite: E.E. 3210 or consent of school.

Analysis of transient conditions in power systems. System parameters. Types of transients. Protective devices and techniques.

E.E. 4350. Materials Science

3-0-3. Prerequisite: E.E. 3320, 3270.

A study of the physical, electrical and optical properties of metals, semiconductors, dielectrics and magnetic materials with emphasis on microscopic as well as macroscopic behavior.

Text: Omar, *Elementary Solid State Physics*.

E.E. 4411. Senior Electrical Engineering Laboratory I

0-3-1. Prerequisite: E.E. 3400. Corequisite: E.E. 3320.

The use, operation and limitations of standard electromagnetic field measurement and signal generating equipment.

E.E. 4421. Senior Electrical Engineering Laboratory II

0-3-1. Prerequisites: E.E. 3330, 3400.

Experimental studies of electromagnetic and electromechanical systems.

E.E. 4430. Project Laboratory

0-3-1. Prerequisite: E.E. 3400. Normally taken by seniors.

Individual experimental investigations and projects tailored to student interests. Projects are selected in consultation with student's faculty adviser.

E.E. 4751. Laser Theory and Applications

3-0-3. Prerequisite: Phys. 2123.

Principles of laser operations. Types of lasers. Survey lectures on the applications of lasers to various fields. Course intended for both E.E. and non-E.E. majors. Also taught as Phys. 3751.

E.E. 4780. Energy Conversion Engineering

3-0-3. Prerequisite: thermodynamics.

Principles of advanced energy conversion for electric power. Operation and engineering considerations. Also taught as M.E. 4780 and N.E. 4780.

Text: Angrist, *Direct Energy Conversion*.

E.E. 4801-2-3-4-5. Special Topics

3-0-3 each. Normally taken by seniors.

New developments in electrical engineering are presented as demand or interest warrants.

E.E. 4900-1-2-3. Special Problems

Credit to be arranged. Normally taken by seniors.

Special engineering problems are assigned according to each student's needs, interests and capabilities.

E.E. 6050. Random Processes

3-0-3. Prerequisite: graduate standing.

An introduction to the concepts of probability theory and random variables with applications to electrical engineering problems.

E.E. 6051. Random Processes

3-0-3. Prerequisite: E.E. 6050 or equivalent.

An introduction to the theory of stochastic processes. Filtering and harmonic analysis. Energy properties. Wiener, Poisson, Gaussian, Markov processes. Engineering applications are emphasized.

E.E. 6061. Statistical Detection Theory

3-0-3. Prerequisite: E.E. 6050, E.E. 3215 or equivalent.

E.E. 6061 and E.E. 6062 constitute a study of the design principles of modern communication systems. Typical topics in E.E. 6061 include: carrier transmission, carrier reception and demodulation in noise, baseband waveforms and multiplexing.

E.E. 6062. Modulation Theory

3-0-3. Prerequisite: E.E. 6061.

A continuation of E.E. 6061. Typical topics include: binary and m-ary digital signaling, optimum receivers, synchronization and comparisons of digital transmission techniques.

E.E. 6063. Methods in Pattern Recognition

3-0-3. Prerequisite: E.E. 6050.

Introduction to pattern recognition. Several approaches to pattern classification, feature extrac-

tion, and training are considered including the use of linear discriminant functions, clustering, gradient methods, and syntactic pattern recognition. Several examples of pattern recognition systems are also included.

E.E. 6071. Communication Circuits and Signals

3-0-3. Prerequisite: graduate standing or consent of school.

Discussion of Fourier transforms and related topics from an intermediate viewpoint, with emphasis on operational skills. Application to electrical networks, sampling, antennas, statistics, optics. Transform-domain reasoning and insight stressed.

E.E. 6072. Fourier Optics and Holography

3-0-3. Prerequisite: E.E. 6071 or consent of school.

Principles of diffraction, lenses, coherent and incoherent imaging, optical information processing and holography presented in a linear systems framework.

E.E. 6081. Information Theory

3-0-3. Prerequisite: E.E. 6050.

Introduction to information theory. The concepts of information, information rate and channel capacity are developed and applied to communication theory problems.

E.E. 6082. Coding

3-0-3. Prerequisite: E.E. 6081.

Coding techniques for efficient, reliable communication are introduced. Techniques studied include parity-check, maximal-length, Hamming, BCH and convolutional codes, Viterbi decoding and coding for burst-noise channels.

E.E. 6092. Computer Communication Systems

3-0-3. Prerequisite: graduate standing.

Provides information necessary for the design or analysis of computer-to-computer data transmission systems.

E.E. 6100. Linear Networks and Systems

3-0-3. Prerequisite: graduate standing.

Introduction to a rigorous treatment of linear systems theory. Topics include theory of vector spaces, linear transformations, state variables, linear dynamical systems, controllability and observability.

E.E. 6101. Time Varying and Nonlinear Systems

3-0-3. Prerequisite: E.E. 6100.

Analysis and design of engineering systems with time varying and/or nonlinear characteristics. Systems representation and properties of

the presentation. Linearization techniques. Stability analysis using Liapunov and Popov's theories.

E.E. 6111. Feedback Control Systems

3-0-3. Prerequisite: E.E. 6100.

Optimal control approach to control system design. Formulation of optimal control problems using state-space programming, calculus of variations and maximum principles.

E.E. 6112. Feedback Control Systems

3-0-3. Prerequisites: E.E. 6050, 6111 or consent of school.

Design techniques for stochastic dynamical systems. Analysis of stochastic systems, state estimation, stochastic control and adaptive control.

E.E. 6113. Feedback Control Systems

3-0-3. Prerequisite: E.E. 6100.

Application of discrete time control to continuous systems. Time and frequency domain analysis of sampled data systems.

E.E. 6131. Optimum Linear Filters

3-0-3. Prerequisite: E.E. 6050, 6100 or consent of school.

Estimation theory, both classical and modern approaches. Applications in communication and control. System identification techniques.

E.E. 6152. Computer Simulation

3-0-3. Prerequisite: graduate standing or consent of school and elementary programming ability.

A study of computational methods for use in the digital simulation of deterministic systems. Several simulation projects are a part of the course.

E.E. 6153. Computer Simulation

3-0-3. Prerequisite: E.E. 6050 or consent of school and elementary programming ability.

Nondeterministic systems—a study of problems associated with generating and analyzing random time series using digital computers. Spectral estimation and statistical inference are among topics covered.

E.E. 6161. Digital Systems Engineering I

3-0-3. Prerequisite: E.E. 3033, 4075 or equivalent.

Functional organization and operation of digital computers. Register level design of computing structures using microoperations and the CDL language. Design of microsequences for arithmetic, logical, timing, control and floating point functions. Comparisons and evaluations of several micro and minicomputers. The design and simulation of a computer structure is required for each student.

E.E. 6162. Digital Systems Engineering II
3-0-3. Prerequisite: E.E. 3033, 4075 or equivalent.

Concepts, technology related to microprogramming. Comparison of hardwired control and microprogrammed control. Design of a hypothetical microprogrammed computer. Design of a computer structure using the INTEL 3000 and AMD 2900 bit slice systems. The use of FPLA's, ROM's, PROM's, EPROM's and sequencers. Several design projects are assigned each quarter.

E.E. 6163. Digital Systems Engineering III
3-0-3. Prerequisite: E.E. 3032, 4075 or equivalent.

A study of information structures using the MIX assembly language. Structures include stacks, deques, queues and circular lists. Memory allocation using sequential allocation, linked lists and doubly linked lists are considered. Arrays and orthogonal lists are considered as special examples. Dynamic storage allocation and the problem of garbage collection is also treated. Several problems are assigned for special credit.

E.E. 6201. Automata Theory
3-0-3. Prerequisite: graduate standing.

An introduction to broad classes of digital systems including computer components as special cases. A detailed study is made of steps leading to optimum design.

E.E. 6202. Automata Theory
3-0-3. Prerequisite: E.E. 6201.

A continuation of digital system study including fault detection and decomposition of systems. Reliability, memory span and quadded logic are also examined.

E.E. 6203. Automata Theory
3-0-3. Prerequisite: E.E. 6202 or consent of school.

An introduction to finite automata through study of sequential circuits. Concepts in modern algebra are developed for direct application to sequential circuits.

E.E. 6251. Applied Electromagnetics
3-0-3. Prerequisite: graduate standing or consent of school.

Advanced electromagnetic theory. Particular and complementary solutions of the wave equation for both discrete and continuous cases. Analysis, synthesis and boundary value problems.

E.E. 6252. Microwaves
3-0-3. Prerequisite: E.E. 6251.

Field analysis of guided waves. Equivalent-circuit theory for microwave systems. Broadband

impedance matching. Passive microwave devices. Microwave cavities. Periodic structures and filters.

E.E. 6253. Antennas
3-0-3. Prerequisite: E.E. 6251.

Classical antenna theory. Antenna array analysis and synthesis. Electromagnetic characterization and design of several antenna types, such as wire, aperture, broadband, parasitic, helical, spiral, microstrip and loop antennas. Introduction to antenna measurements.

E.E. 6301. Electrooptics
3-0-3. Prerequisite: graduate standing.

Introduction to electrooptics with emphasis on lasers and modern optics. Topics include Gaussian beams, laser theory and laser types, mode-locking, Q-switching, harmonic generation, parametric oscillation, and light modulation. Applications discussed include high power laser systems and optical communications.

E.E. 6351. Advanced Electrical Measurements
3-3-4. Prerequisite: graduate standing.

Theory of measurement and practical application of instrumentation. Measurement uncertainties, system modeling, component parts of system accuracy, data accumulation, reduction and interpretation are considered.

E.E. 6361. Integrated Circuits
3-0-3. Prerequisite: graduate standing.

Design, fabrication and application considerations of monolithic linear ICs. Analysis of the unconventional circuitry contained in typical integrated circuits. Applications of available linear ICs.

E.E. 6381. Low-Noise Electronic Design
3-3-4. Prerequisite: graduate standing or consent of school.

Sources of noise in electronic instrumentation design and employment of design techniques to reduce the effects of noise.

E.E. 6401. Advanced Network Theory
3-3-4. Prerequisite: graduate standing.

Special techniques of network analysis that are not usually covered in undergraduate curricula. Topics include networks involving active elements, multiport or multiterminal elements, pathological elements.

E.E. 6402. Advanced Network Theory
3-3-4. Prerequisite: graduate standing.

A survey of various techniques of passive and log filter design. The objective is to enable the student to design practical filters with understanding of underlying principles.

E.E. 6403. Advanced Network Theory
3-3-4. Prerequisite: graduate standing.
Techniques of synthesizing networks using active elements such as gyrators, controlled sources, immittance transducers, operational amplifiers. Practical filter design using these elements.

E.E. 6412. Time-Domain Synthesis of Linear Networks
3-0-3. Prerequisite: graduate standing.

Methods of specifying a network function to give a prescribed time-domain response. Mathematical techniques suitable for obtaining the time-domain approximating functions.

E.E. 6413. Digital Filters
3-0-3. Prerequisite: graduate standing or consent of school.

An introduction to the theory and application of digital signal processing. Fourier and z-transform representations of discrete signals and systems. Design and implementation of digital filters and computational methods of discrete spectrum analysis.

E.E. 6414. Advanced Digital Signal Processing
3-0-3. Prerequisite: E.E. 6413.

A selection of advanced topics in digital signal processing. Topics include multidimensional signal processing, homomorphic systems and autoregressive modelling.

E.E. 6415. Digital Processing of Speech Signals
3-0-3. Prerequisite: E.E. 4078 or E.E. 6413.

A detailed treatment of the theory and application of digital speech processing. Provides fundamental knowledge about speech signals and speech processing methods and about how digital techniques are applied in speech transmission, speech synthesis, speech recognition and speaker verification.

E.E. 6421. Advanced Network Theory II
3-0-3. Prerequisite: graduate standing or consent of school.

An introduction to applied combinatorics including combinations, permutations, recursion, partition, generating functions, inclusion and exclusion, rook polynomials and Polya's theorem.

E.E. 6422. Advanced Network Theory II
3-0-3. Prerequisite: graduate standing.
Topological analysis of networks. Current interest topics presented from a linear-graph aspect. Concepts and techniques of network and system analysis by topological methods.

E.E. 6431. Electroacoustics
3-0-3. Prerequisite: graduate standing or consent of school.

The practical application of electrical circuit theory to the solution of acoustical problems. Terminology. Basic solutions to the wave equation. Mechanical and acoustical circuits. Transducers. Radiation impedances. Acoustical elements. Direct radiator loudspeakers. Acoustics of enclosures. Loudspeaker system synthesis. Horn loudspeakers.

E.E. 6451. Electrical Properties of Materials
3-0-3. Prerequisite: graduate standing or consent of school.

Basis of quantum mechanical formalism and modeling to serve as an introduction to the modern study of electrical properties of materials.

E.E. 6452. Magnetic and Dielectric Properties of Materials
3-0-3. Prerequisite: E.E. 6451 or consent of school.

Dielectrics, piezo- and ferroelectrics and their application to electromechanical devices. Quantum basis of magnetism. Magnetic interactions, domains, resonance and devices.

E.E. 6453. Solid-state Electronic Devices
3-0-3. Prerequisite: graduate standing or consent of school.

Study of charge and energy transport in semiconductors with applications in pn junction, interface and thin film, optoelectronic and bulk-effect devices.

E.E. 6461. Modern Magnetic Materials and Devices
3-0-3. Prerequisite: E.E. 6452 or consent of school.

Basic operation and design of magnetic memories and microwave devices. Crystal structure, chemical composition. Properties of ferrites, garnets and orthoferrites.

E.E. 6500. Introduction to Management and Control of Energy Systems
3-0-3. Prerequisite: E.E. 6100 or consent of school.

Fundamentals of static as well as dynamic system theory as applied to typical energy engineering problems. Optimization theory, decision analysis techniques for large-scale systems.

E.E. 6501. Planning of Power Systems
3-0-3. Prerequisite: E.E. 4019 or consent of school.

An introduction to planning procedures for large scale technical operations. Technical and economic constraints on planning. Techniques for formulation of rational planning problems.

E.E. 6502. Control and Operation of Interconnected Power Systems

3-0-3. Prerequisite: E.E. 4019, 6100 or consent of school.

Power flow analysis techniques. Modern control of power systems with emphasis on security, economic and environmental issues.

E.E. 6503. Evaluation of Power System Reliability

3-0-3. Prerequisite: E.E. 4019 or consent of school.

Techniques for the study of power system reliability. Probabilistic models for power system performance. Techniques for subsystem and composite system reliability analysis.

E.E. 6504. Computer Applications in Power Systems

3-0-3. Prerequisite: E.E. 4075.

A study of problems in applying the digital computer to real-time control. The digital computer and its supporting control equipment are treated as devices in several control applications. Problems which are considered include sampling, input buffering, control algorithms, error checking, real-time monitoring and data conversion. Applications in the power area are protective relaying and turbine control. Several problems are assigned which require a knowledge of INTEL 8080 assembly language programming.

E.E. 6511. Transmission Lines

3-3-4. Prerequisite: graduate standing.

A study of electric power transmission line parameters, models and techniques for analysis of steady state and transient conditions. A.C., D.C., HV and underground transmission.

E.E. 6521. Power System Stability

3-0-3. Prerequisite: E.E. 4019, 6100.

Methods for stability analysis of interconnected power systems. System modeling, analysis techniques for determination of static and dynamic stability.

E.E. 6530. Power Semiconductor Devices

3-0-3. Prerequisite: graduate standing or consent of school.

The study of the physical considerations involved in the use of heavy-current semiconductor devices; the study of magnetic circuits, transformers and their applications.

E.E. 6531. Solid-State Power Conversion

3-0-3. Prerequisite: graduate standing or consent of school.

The study of the physical and electrical considerations involved in the analysis and design of solid-state inverters and converters.

E.E. 6750. Systems Design Methodology

2-3-3. Prerequisite: graduate standing or consent of school.

An introduction to complex system design, interdisciplinary. Also taught as A.E. 6750, M.E. 6750.

E.E. 6751-2. Complex System Design

2-4-3 each. Prerequisite: graduate standing or consent of school.

The class acts as an interdisciplinary team to carry out a significant relevant preliminary design of a complex system. Also taught as A.E. 6751-2, M.E. 6751-2.

E.E. 6760. Atomic Collisions

3-0-3. Prerequisite: graduate standing in science or engineering.

A discussion of the techniques by which atomic collisions phenomena are studied, includes scattering of ions and electrons in gases and scattering from solid surfaces. Also taught in the School of Physics.

E.E. 6771. Engineering Computer Software Systems

3-3-4. Prerequisite: N.E. 6770 or consent of school.

Computer programming for real-time process control systems in complex multiple-task device-oriented environments. Subjects include assembler programming, operating systems and real-time systems on minicomputers. Also taught as N.E. 6771.

E.E. 6772. Advanced Computer Interfacing and Digital Design

2-3-3. Prerequisite: consent of school. For non-electrical engineering students, and for electrical engineering students whose major program area is not computers or digital systems.

A study of system design using MSI and LSI chips, and programmable digital devices as system modules. Subjects include Boolean optimization and register transfer design techniques. Also taught as C.E. 6772, M.E. 6772 and N.E. 6772.

E.E. 6773. Computer Control of Real-time Systems

3-3-4. Prerequisite: consent of school. For non-electrical engineering students, and for electrical engineering students whose major program area is not computers or digital systems.

A study of concepts common to all computer controlled real-time systems. Subjects include evolution of time sets, vectored interrupts and statistical alarm conditions. Also taught as C.E. 6773, M.E. 6773 and N.E. 6773.

E.E. 6965. Power System Relaying

3-3-4. Prerequisite: E.E. 4019, consent of school.

Principles and techniques of electric power system protection. Application of relaying techniques for system stabilization, protection of high voltage transmission system and substations. Coordinated field trips and demonstrations.

E.E. 6976. Advanced Electrical Transients

3-0-3. Prerequisite: graduate standing or consent of instructor.

Development and application of those aspects of complex variable and transform theory which are helpful in the study of transients and which are particularly useful to electrical engineers in general.

E.E. 7000. Master's Thesis

E.E. 7051-2-3. Advanced Communication Theory

3-0-3 each. Prerequisite: E.E. 6051, 6062.

Latest developments in communications are treated in lecture and seminar. Emphasis on current literature and open research areas.

E.E. 7101. Advanced Feedback Control Theory

3-0-3. Prerequisite: consent of school.

Advanced techniques for analysis and design of automatic control systems.

E.E. 7251-2-3. Advanced Electromagnetic Theory

3-3-4 each. Prerequisite: E.E. 6251 or consent of school.

Topics of fundamental importance in electromagnetics. Advanced developments in the fields of antennas, propagation, and microwave theory and practice.

E.E. 7999. Preparation for Doctoral Qualifying Exams

Non-credit.

Preliminary doctoral examination.

E.E. 8001-2-3. Seminar

1-0-1 each. Prerequisite: graduate standing and consent of school.

E.E. 8011-2-3. Seminar

1-0-0 each. Prerequisite: graduate standing and consent of school.

E.E. 8140 through 8149. Special Topics

1-0-1 each.

Special topics of unusual current interest: introductory treatments of new developments in electrical engineering.

E.E. 8240 through 8249. Special Topics

2-0-2 each.

E.E. 8340 through 8349. Special Topics

3-0-3 each.

E.E. 8430 through 8439. Special Topics

4-0-4 each.

E.E. 8440 through 8449. Special Topics

5-0-5 each.

E.E. 8500-1-2-3. Special Problems

Credit to be arranged.

Problems meeting the special interests of the student. Approval to schedule must be obtained in advance of registration.

E.E. 9000. Doctoral Thesis

ENGINEERING GRAPHICS

See Civil Engineering.

ENGINEERING SCIENCE AND MECHANICS

E.S.M. 1101. Introduction to Engineering

2-3-3.

The engineer and design, relation between the student's curriculum and his or her career in engineering. Emphasis placed on student participation in creative design process.

Text: at the level of Beakley and Leach, *Engineering: An Introduction to a Creative Profession*.

E.S.M. 1750. Introduction to Bioengineering

3-0-3.

Bioengineering aspects of human body including its mechanics, nervous system control, material properties and biological fluid flows. Diagnostic techniques and assisting and replacement prosthetic devices. Also listed as A.E. 1750, E.E. 1750, M.E. 1750.

E.S.M. 1901 through 1909. Special Problems in Engineering Science

3-0-3, maximum. Prerequisite: freshman standing.

Individual study and analysis of problems of current and future interest in engineering and science, approved by faculty adviser.

E.S.M. 2101. Engineering Design I

0-3-1. Prerequisite: E.S.M. 1101 or consent of school.

Study of a problem that arises from a need of society. Proposals for a creative solution studied to select best design.

E.S.M. 2102. Engineering Design II

0-6-2. Prerequisite: E.S.M. 2101.

Continuation of E.S.M. 2101. Solution of design problem to be completed, a model to be submitted as part of final report.

E.S.M. 2201. Statics

3-0-3. Prerequisite: Phys. 2121. Prerequisite or corequisite: Math. 2307.

Elements of statics in two- and three-dimensions, centroids, analysis of structures and machines, friction.

Text: at the level of Beer and Johnston, *Vector Mechanics for Engineers; Statics*.

E.S.M. 2901 through 2909. Special Problems in Engineering Science

3-0-3, maximum. Prerequisite: sophomore standing.

Individual study and analysis of problems of current and future interest in engineering and science, approved by faculty adviser.

E.S.M. 3111. Experimental Methods in Engineering Science

2-3-3. Prerequisite: E.E. 3400, Math. 2309, E.S.M. 3201, 3301, Engl. 3023.

Methods used to observe behavior of physical parameters in engineering problems, photo-optics, signal analysis, transducers and transducer circuits, models and analogies.

Text: at the level of Tuve and Domholdt, *Engineering Instrumentation*.

E.S.M. 3201. Dynamics I

3-0-3. Prerequisite: E.S.M. 2201, Math. 2307.

Kinematics and kinetics of rigid bodies in plane motion.

Text: at the level of Higdon, Stiles, Davis and Evces, *Dynamics*.

E.S.M. 3202. Dynamics II

3-0-3. Prerequisite: E.S.M. 3201.

Kinematics and kinetics of three-dimensional motion of rigid bodies.

Text: at the level of Higdon, Stiles, Davis and Evces, *Dynamics*.

E.S.M. 3301. Mechanics of Deformable Bodies

5-0-5. Prerequisite: E.S.M. 2201. Prerequisite or corequisite: Math. 2308.

Definition and analysis of strain and stress, ap-

plications to axially loaded elements, torsion of circular shafts and bending of beams, introduction to simple plasticity and to column stability.

Text: at the level of Popov, *Introduction to the Mechanics of Solids*.

E.S.M. 3302. Mechanics of Materials

3-0-3. Prerequisite: E.S.M. 3301.

Analysis and design of beams (using singularity functions), various structural elements (using energy methods), thick-walled cylinders, rotating discs, curved beams. Theories of failure.

Text: at the level of Budynas, *Advanced Strength and Applied Stress Analysis*.

E.S.M. 3451. Computer Applications in Engineering Science and Mechanics

2-3-3. Prerequisite or corequisite: E.S.M. 3302, 3501, 4210 or consent of school.

Introduction to the use of the digital computer. FORTRAN languages, computer solutions of problems in statics, dynamics, mechanics of deformable solids, vibrations and fluid mechanics.

E.S.M. 3501. Fluid Mechanics

5-0-5. Prerequisite: E.S.M. 3202. Prerequisite or corequisite: Math. 2308.

Kinematics of fluid motion, material and spatial coordinates, acceleration, continuity, vorticity, perfect fluid motion, introduction to the motion of a viscous fluid.

Text: at the level of Owczarek, *Introduction to Fluid Mechanics*.

E.S.M. 3701. Statics

3-0-3. Prerequisite: Arch. 2301, Math. 1309, Phys. 2111.

Elements of coplanar statics, particle and rigid body equilibrium, centroids, centers of gravity, distributed loads, analysis of structures and beams, shear and bending moment.

Text: at the level of Beer and Johnston, *Mechanics for Engineers; Statics*.

E.S.M. 3702. Mechanics of Materials

3-0-3. Prerequisite: E.S.M. 3701.

Simple stresses and strains, mechanical properties of materials, Hooke's Law, moments of inertia of areas, analysis and design of beams and columns, deflection of beams.

Text: at the level of Popov, *Mechanics of Materials*.

E.S.M. 3711. Dynamics

5-0-5. Prerequisite: E.S.M. 2201.

Kinematics of particles and rigid bodies, kinetics of translation, rotation and plane motion, work and energy relations.

Text: at the level of Work, *A Programmed Instruction in Dynamics*.

E.S.M. 3750. Introduction to Biofluid Dynamics

3-0-3. Prerequisite: Math. 2309, Phys. 2123 or consent of instructor.

Introduces students to the study of blood flow in the cardiovascular system, with emphasis on the modeling of such flows and the potential of flow studies for clinical research application.

E.S.M. 3901 through 3909. Special Problems in Engineering Science

Credit to be arranged. Prerequisite: junior standing.

Individual study and analysis of problems of current and future interest in engineering and science, approved by faculty adviser.

E.S.M. 4111. Introduction to Experimental Stress Analysis

1-6-3. Prerequisite: E.S.M. 3301 or equivalent, senior standing.

Plane stress analysis using transmitted light photoelasticity and photoelastic models, study of surface strain using resistance strain gauges, transducer design and application.

Text: at the level of Holister, *Experimental Stress Analysis*.

E.S.M. 4122. Project in Engineering Science I

0-3-1. Prerequisite: Senior standing in Engineering Science.

Through discussions with his faculty adviser and other members of the faculty, the student will determine the design-related engineering problem that he wishes to study. A detailed written project proposal will be submitted to and approved by the student's faculty project adviser prior to the end of the quarter.

E.S.M. 4123. Project in Engineering Science II

0-6-2. Prerequisite: E.S.M. 4122.

Continuation of E.S.M. 4122. Student will complete an experimental and/or a theoretical investigation of an engineering problem and submit a written report for the approval of his faculty project adviser.

E.S.M. 4201. Intermediate Dynamics I

3-0-3. Prerequisite: E.S.M. 3202 or consent of school.

Kinematics and kinetics of particles and particle systems, applications include motion in resisting medium, redistribution of mass, central force motion, effects of earth rotation.

Text: at the level of Marris and Stoneking, *Advanced Dynamics*.

E.S.M. 4202. Intermediate Dynamics II

3-0-3. Prerequisite: E.S.M. 4201 or consent of school.

Two- and three-dimensional motion of a rigid body, Euler's equations, introduction to energy methods and Lagrange's equations.

E.S.M. 4210. Mechanical Vibrations I

3-0-3. Prerequisite: E.S.M. 3201, 3301 and Math. 2309 or their equivalent.

Single degree-of-freedom system, two degrees-of-freedom system, and finitely many degrees-of-freedom system, complex representation, applications.

Text: at the level of Timoshenko, Young, Weaver, *Vibration Problems in Engineering*.

E.S.M. 4211. Mechanical Vibrations II

3-0-3. Prerequisite: E.S.M. 4210 and E.S.M. 3302 or equivalent. Fall quarter.

Complex representation, step and impulse loads, many degrees of freedom, influence coefficients, matrix methods, stability of solution, vibrations of strings, beams and membranes, approximate methods.

Text: at the level of Timoshenko, Young, Weaver, *Vibration Problems in Engineering*.

E.S.M. 4301. Mechanics of Deformable Bodies

3-0-3. Prerequisite: E.S.M. 3301.

Small strain linear elasticity in two- and three-dimensions, applications in generalized plane stress and plane strain, torsion and bending of noncircular prisms.

E.S.M. 4302. Stress Analysis

3-3-4. Prerequisite: E.S.M. 4301.

Continuation of E.S.M. 4301, further treatment of torsion and bending, strain energy, introduction to thin plates and simple shells, approximation methods.

E.S.M. 4351. Continuum Mechanics

3-0-3. Prerequisite: Math. 2309, E.S.M. 3301.

Geometrical foundations, analysis of stress and deformation, balance laws, constitutive equations, finite and infinitesimal elasticity.

E.S.M. 4451. Biomechanics

3-0-3. Prerequisite: Math. 2309 or equivalent, E.S.M. 3301 or equivalent.

Elastic and inelastic behavior of biomaterials, muscle mechanics, mechanical modeling of biological structures. Hemodynamics, properties of blood, flow in the circulatory system.

E.S.M. 4760. Engineering Acoustics and Noise Control I

3-0-3. Prerequisite: senior standing.

Acoustics related to noise and its control, acoustic terminology, wave propagation, solutions to the wave equation, instrumentation,

sound field in large and small rooms, noise legislation. Also taught as A.E. 4760, M.E. 4760.

E.S.M. 4761. Engineering Acoustics and Noise Control II

3-0-3. Prerequisite: E.S.M. 4760 or equivalent.

Continuation of E.S.M. 4760 emphasizing techniques for the solution of noise problems. Vibration isolation, energy absorption, dissipative and reactive mufflers, enclosures, barriers, properties of materials, panel damping. Also taught as A.E. 4761, M.E. 4761.

E.S.M. 4770. Structural Integrity and Durability

3-0-3. Prerequisite: E.S.M. 3301 or A.E. 2101.

Simple stress-concentration problems involving plastic deformation, residual stresses, hysteresis, creep and relaxation. Introduction to fatigue and fracture mechanics. Crack-growth calculations and wearout models. Also taught as A.E. 4770.

E.S.M. 4801 through 4809. Special Topics in Engineering Science

1-0-1 through 9-0-9, respectively. Prerequisite: senior standing.

Special courses not included in regular course offerings.

E.S.M. 4901 through 4909. Special Problems in Engineering Science

Credit to be arranged. Prerequisite: senior standing.

Individual study and analysis of problems of current and future interest in engineering and science, approved by faculty adviser.

E.S.M. 6111. Theory of Experimental Stress Analysis

2-3-3. Prerequisite: E.S.M. 6341 or consent of school. Spring quarter.

Study of surface stress and strain using brittle coatings and electrical resistance strain gauges, strain gauge circuits, static and dynamic problems, transducer design and circuits.

E.S.M. 6117. Experimental Photomechanics I

2-3-3. Prerequisite: E.S.M. 3301 or equivalent.

Polarized light, mathematical description, light transformations, photoelastic models, use of transmitted light for stress analysis in two dimensional problems, birefringent coatings.

E.S.M. 6118. Experimental Photomechanics II

2-3-3. Prerequisite: E.S.M. 6117.
Three dimensional photoelastic stress analysis using transmitted light and scattered light methods, numerical methods, Moiré fringes, holographic interferometry.

E.S.M. 6201. Advanced Dynamics I

3-0-3. Prerequisite: E.S.M. 4210 and Math. 2309, or equivalent. Fall quarter.

Kinematics and kinetics of particles, angular velocity, inertia properties, rigid body dynamics, generalized coordinates and forces, nonholonomic systems, solutions by vector methods and Lagrange's equations.

E.S.M. 6202. Advanced Dynamics II

3-0-3. Prerequisite: E.S.M. 4202 or 6201. Winter quarter.

A continuation of E.S.M. 6201. Hamilton's principle, Hamilton's canonical equations, energy and momentum integrals, Hamilton-Jacobi theory, study of selected papers from recent dynamics literature.

E.S.M. 6221. Vibrations I

3-0-3. Prerequisite: Math. 4582 or consent of school. Fall quarter.

Lagrange's equations, small oscillations of conservative and nonconservative systems, natural modes; response of multi-degree-of-freedom systems; introduction to vibration of continuous systems.

E.S.M. 6222. Vibrations II

3-0-3. Prerequisite: E.S.M. 6221, 6341. Winter quarter.

Free and forced longitudinal, torsional and lateral vibration of bars; vibration of membranes, plates, shells and extended elastic bodies; approximate methods.

E.S.M. 6223. Wave Propagation in Solids

3-0-3. Prerequisite: E.S.M. 6222 or consent of school. Spring quarter.

Wave propagation in elastic solids; dilatational equivoluminal and surface waves, reflection and refraction; waves in structural elements; analysis of impact problems.

E.S.M. 6241. Gyroscopic Motion and Devices

3-0-3. Prerequisite: E.S.M. 6201 or equivalent. Spring quarter, odd years.

Motion of a rigid body about a fixed point, the top, precession and nutation of the earth, the gyroscope, rate and integrating gyros, the monorail, ship stabilizers.

E.S.M. 6261. Space Mechanics I

3-0-3. Prerequisite: graduate standing. Fall quarter, even years.

The two-body problem, Kepler's equation, transfer orbits, Hohmann transfer, dynamics of rocket motion, rocket staging.

E.S.M. 6262. Space Mechanics II

3-0-3. Prerequisite: E.S.M. 6261 or consent of school. Winter quarter, even years.

Celestial sphere, aberration, parallax, Laplace's and Gauss' methods, three- and n-body problems, Lagrangian points, Lagrange brackets, perturbations of an oblate planet, and atmospheric drag.

E.S.M. 6281. Random Vibrations I

3-0-3. Prerequisite: Math. 4215 and E.S.M. 4210, or consent of school. Winter quarter, even years.

Statistical analysis of mechanical systems, correlation function, power spectral density, response to random inputs, method of normal modes, fatigue failures, nonstationary inputs, vibration of beams.

E.S.M. 6282. Random Vibrations II

3-0-3. Prerequisite: E.S.M. 6281. Spring quarter, even years.

Continuation of E.S.M. 6281. Advanced engineering problems in random theory, nonstationary random inputs and response, measurement of power spectra, Fokker-Planck techniques, nonlinear systems.

E.S.M. 6301. Advanced Strength of Materials

3-0-3. Prerequisite: Math. 2309, E.S.M. 3301. Summer quarter.

Shear centers for beams, analyses of stresses and deflections in unsymmetrical bending, stresses and deflections in curved flexural members, beams on elastic supports.

E.S.M. 6321. Applied Elasticity I

3-0-3. Prerequisite: E.S.M. 3301 or equivalent. Fall quarter.

Analysis of stress and strain, stress-strain relations, equilibrium, compatibility and boundary conditions, simple three-dimensional applications, plane elasticity problems in Cartesian and polar coordinates.

E.S.M. 6322. Applied Elasticity II

3-0-3. Prerequisite: E.S.M. 6321. Winter quarter.

Continuation of Applied Elasticity I, torsion and flexure of bars, introduction to thermoelasticity, finite-element, finite-difference approximations and relaxation method as applied to elasticity problems.

E.S.M. 6341. Theory of Elasticity I

3-0-3. Prerequisite: E.S.M. 3301 and Math. 2309 or consent of school. Fall quarter.

Introduction to generalized tensors, analysis of deformation, equations of motion, linearly elastic materials, formulation of the first, second and mixed boundary value problems.

E.S.M. 6342. Theory of Elasticity II

3-0-3. Prerequisite: E.S.M. 6341 or consent of school. Winter quarter.

Continuation of E.S.M. 6341, linear elasticity, Saint-Venant's theory of torsion, bending of beams, Love's strain function, Galerkin vector, Papkovitch-Neuber representation, stress potentials, Airy's stress function.

E.S.M. 6343. Theory of Elasticity III

3-0-3. Prerequisite: E.S.M. 6342 or consent of school. Spring quarter.

Continuation of E.S.M. 6342, variational formulation of elasticity, energy theorems, introduction to thermoelasticity, representation of biharmonic functions by analytic functions of a complex variable.

E.S.M. 6361. Theory of Elastic Stability I

3-0-3. Prerequisite: E.S.M. 3301, Math. 4582 or consent of school. Winter quarter.

Various stability methods and their applicability, the elastica problem, snap and bifurcation buckling, stability of conservative systems, buckling of beams on elastic foundation, lateral buckling.

E.S.M. 6362. Theory of Elastic Stability II

3-0-3. Prerequisite: E.S.M. 6361 or consent of school. Spring quarter.

Stability of various systems—velocity dependent, conservative, dissipative, circulatory and nonstationary, with examples of each, recent developments in elastic stability theory.

E.S.M. 6371. Theory of Plates

3-0-3. Prerequisite: graduate standing and Math. 4582 or equivalent. Spring quarter.

Von Karman theory of plates, pure bending of laterally loaded rectangular and circular plates, approximate methods, nonlinear considerations, stiffened and layered anisotropic plates.

E.S.M. 6372. Theory of Shells

3-0-3. Prerequisite: E.S.M. 6371 or consent of school. Summer quarter.

Stresses and deformation of shells with and without bending under various loading conditions, shells forming surfaces of revolution, hyperbolic paraboloidal and elliptic paraboloidal shells.

E.S.M. 6381. Plasticity

3-0-3. Prerequisite: E.S.M. 6341 or consent of school. Spring quarter.

Stress-strain relations in three dimensions, three-dimensional yield conditions and flow laws, thick-walled tube and sphere, torsion of bars, slip line fields, technological processes, plates.

E.S.M. 6391. Finite Elasticity

3-0-3. Prerequisite: E.S.M. 4351 or consent of school. Winter quarter.

Kinematics of finite deformation, stress, deformation and strain tensors, classical theory of finite elasticity for isotropic materials, introduction to simple materials.

E.S.M. 6401-2. Optimization Techniques I and II

3-0-3 each. Prerequisite: graduate standing. Winter and spring quarters, even years.

Applications of calculus of variations to optimization of engineering systems and processes, end and corner conditions, discontinuous optimal processes, control and state variable inequality constraints, direct methods, etc.

E.S.M. 6411. Energy Methods in Mechanics

3-0-3. Prerequisite: E.S.M. 3301, Math. 4582 or consent of school. Summer quarter.

Virtual work, minimum total potential energy, minimum complementary energy, Castigliano's theorems, applications of calculus of variations, Rayleigh-Ritz method.

E.S.M. 6450. Finite Elements, Boundary Elements and Other Computational Methods in Mechanics I

3-0-3. Prerequisite: graduate standing in engineering. Fall quarter.

Review of weighted residual methods; linear solid and structural problems; finite element variational method—assumed displacement method; element interpolation, integration; assembly and solution of large systems of equations; convergence of finite element method; edge function method; boundary elements methods, plane and 3-D elasticity.

E.S.M. 6451. Finite Elements, Boundary Elements and Other Computational Methods in Mechanics II

3-0-3. Prerequisite: E.S.M. 6450 or consent of instructor. Winter quarter.

Mixed and hybrid methods; assumed stress and multifield finite elements; combined finite elements and boundary elements; plate and shell problems; application to fracture—composites; finite deformation analysis; alternate stress and strain measures; objective stress rates—strain rates; finite element rate (incremental) methods.

E.S.M. 6452. Finite Elements, Boundary Elements and Other Computational Methods in Mechanics III

3-0-3. Prerequisite: E.S.M. 6451 or consent of instructor. Spring quarter.

Rate (incremental) analysis of finite strain problems; finite elasticity-finite strain elastoplasticity; alternative variational rate finite element methods; stability; transient dynamic response;

current developments in discrete approximations in fluid flow.

E.S.M. 6453. Finite Elements, Boundary Elements and Other Computational Methods in Mechanics IV

3-0-3. Prerequisite: E.S.M. 6452 or consent of instructor. Summer quarter.

Selected advanced topics of current topical interest in research in solid and fluid mechanics. Selected topics from other areas of engineering science. Content varies from year to year.

E.S.M. 6501-2. Fluid Mechanics I and II

3-0-3. Prerequisite: graduate standing. Fall and winter quarters.

Mechanical principles of rational fluid mechanics. Kinematics, balance laws, examples of constitutive equations of fluids including perfect, Navier-Stokes, Rivlin-Ericksen fluids, potential flows, viscometric flows, introduction to approximate solutions and boundary-layer theory.

E.S.M. 6751-2. Complex Systems Design

2-4-3 each. Prerequisite: graduate standing of any school or senior with consent of school.

Interdisciplinary team design of systems of current interest to society which have large technological factors. Individual research and interaction with nonuniversity resource persons and faculty. Grades based on oral and written reports. Cross-listed with A.E., E.E., C.E., C.P., I.Sy.E. and M.E.

E.S.M. 6760-1-2. Acoustics I, II and III.

3-0-3 each. Prerequisite: Math. 4349 or consent of school.

Introductory analytical methods, and stochastic process, the wave equation in a compressible fluid, radiation of wind, reflection, refraction, diffraction and scattering of sound waves, duct acoustics. Also listed as A.E. 6760-1-2 and M.E. 6760-1-2.

E.S.M. 6763. Noise Reduction and Control (Industrial Applications)

3-0-3. Prerequisite: E.S.M. 6760, E.S.M. 4760 or equivalent.

Methods of noise reduction and control applied to systems in industry. Measurement of sound power, material acoustic properties, barriers, enclosures, mufflers, vibration reduction and damping methods. Also taught as A.E. 6763, M.E. 6763.

E.S.M. 6764. Ocean Acoustics

3-0-3. Prerequisite: Geol. 4300 or consent of school. Math. 4321, 4582. E.S.M. 6760 recommended.

Propagation of sound waves in the oceans, stress-strain relationships, asymptotic ray theory. Propagation in shallow water and deep water. Also taught as A.E. 6764, Geol. 6764, M.E. 6764.

E.S.M. 7000. Master's Thesis

E.S.M. 7101-2-3-4-5. Master's Report

1-0-1 through 5-0-5, respectively. Prerequisite: consent of adviser.

A theoretical and/or experimental investigation in a major area of interest of an M.S. candidate. Written report must be approved by faculty adviser. Required of all M.S. students not doing a thesis.

E.S.M. 7201. Mechanics of Composite Materials

3-0-3. Prerequisite: E.S.M. 6371, E.S.M. 6321 or 6341, or consent of instructor. Summer quarter.

Basic theory of anisotropic elasticity, equations for laminated composites, properties of laminates, estimation of the composite anisotropic moduli, bending, buckling and failure criteria of laminates.

E.S.M. 7221. Nonlinear Vibrations I

3-0-3. Prerequisites: E.S.M. 4210, 6201 and Math. 4582 or their equivalents. Winter quarter, odd years.

Vibrations of autonomous one degree-of-freedom systems, method of approximated characteristics, topological methods, analysis of singularities and stability, free damped nonlinear vibrations, self-excited oscillations.

E.S.M. 7222. Nonlinear Vibrations II

3-0-3. Prerequisite: E.S.M. 7221. Spring quarter, odd years.

Nonlinear vibrations of nonautonomous one degree-of-freedom systems, method of Duffing, perturbation method, Bogoliuboff method, Ritz-averaging method, stability criteria, subharmonics, two degree-of-freedom systems.

E.S.M. 7231. Wave Propagation in Continuous Media

3-0-3. Prerequisite: E.S.M. 6501 or consent of school. Fall quarter, odd years.

The theory of propagation of singular surfaces in three dimensions, Hadamard's lemma, Maxwell's theorem, compatibility conditions for weak singular surfaces, general balance at a singular surface, weak waves, applications to wave propagation in various materials.

E.S.M. 7371. Stability of Shells

3-0-3. Prerequisite: E.S.M. 6361, 6372. Fall quarter.

Linear and nonlinear theories for shell buck-

ling, stability of thin stiffened and unstiffened plates and cylindrical shells under various loads, edge effects, imperfection sensitivity studies.

E.S.M. 7501. Viscoelasticity

3-0-3. Prerequisite: E.S.M. 6391, 6501 or consent of school. Spring quarter.

The theory of viscoelasticity, simple fluids, viscometric flows and the determination of material functions.

E.S.M. 7511. Analytical Fracture Mechanics

3-0-3. Prerequisite: E.S.M. 6341 and Math. 4321 or equivalent. Fall quarter.

Half-plane problems. Symmetric crack problems. Crack-extension criteria. Antisymmetric crack problems. Williams' series. Effect of nearby boundaries. Crack growth under cyclic loading. Design problems.

E.S.M. 7750. Biofluid Mechanics

3-0-3. Prerequisite: A.E. 6000 or E.S.M. 6501, 6502 or consent of instructor. Fall quarter.

A unified treatment on hemorheology, hemodynamics, pulsatile flows, microcirculation, joint lubrication, pulmonary physiology, etc., with emphasis on quantitative approach. Also listed as A.E. 7750.

E.S.M. 7999. Preparation for Doctoral Qualifying Examination

Credit to be arranged. Prerequisite: consent of adviser.

E.S.M. 8000-1-2-3. Graduate Seminar

1-0-1 each.

E.S.M. 8103-13-23-33-43-53. Special Topics

3-0-3. Prerequisite: consent of adviser.

Special ad hoc courses not included in regular E.S.M. graduate course offerings.

E.S.M. 8104-14-24-34-44-54. Special Topics

4-0-4 each. Prerequisite: consent of adviser.

Special ad hoc courses not included in regular E.S.M. graduate course offerings.

E.S.M. 8105-15-25-35-45-55. Special Topics

5-0-5 each. Prerequisite: consent of adviser.

Special ad hoc courses not included in regular E.S.M. graduate course offerings.

E.S.M. 8501-2-3. Special Problems

Credit to be arranged. Prerequisite: consent of adviser.

Individual study and analysis of problems of current and future interest in engineering and science.

E.S.M. 8999. Doctoral Thesis Preparation

Credit to be arranged.

For student in preliminary stages of formulat-

ing doctoral research program but who has not obtained formal approval of thesis topic.

E.S.M. 9000. Doctoral Thesis

ENGLISH

Engl. 0010. Remedial English 2-3-3.

Special attention given to developing the vocabulary and basic skills in reading and writing for students who need additional preparation for college-level English. Offered on pass-fail basis only. Lectures, exercises, laboratory. Cannot be counted for credit toward graduation.

Engl. 0020. Writing the Impromptu Essay 3-0-3.

Special attention given to developing basic skills in writing for students who need additional preparation for college-level English. Offered on pass-fail basis only. Lectures, exercises. Cannot be counted for credit toward graduation.

Engl. 0050. Efficient Reading 2-0-0.

Mechanics of reading: intensive, rapid, skimming. Learning and performing reading processes based on reading objectives and language levels of difficulty.

Engl. 1001-2-3. Analysis of Literature and Language

3-0-3 each. Freshman year. Courses must be taken in numerical sequence.

Analysis of selected works, emphasizing relationship of content and form, and of audience and style. Intensive practice in written composition about the literature studied. Discussion, exercises, papers.

Engl. 1031-2-3. English for International Students

5-0-5 each. Freshman year, consecutive quarters: To be taken by foreign students in lieu of Engl. 1001-2-3.

Introduction to written and spoken English, stressing pronunciation, idioms and language appropriate to American social situations and customs. English 1033 includes some study of literature.

Engl. 2001-2-3. Survey of the Humanities 3-0-3 each. Prerequisite: Engl. 1001-2.

A sequence of courses studying the contribution of several Western civilizations from the Greeks to modern times as revealed in literature. Lectures, reports, papers, quizzes.

Engl. 2004. Survey of English Literature

3-0-3. Prerequisite: Engl. 1001-2. May be substituted for Engl. 2003

A study of English literature since Shakespeare, with emphasis on significant figures and their works. Lectures, reports, papers, quizzes.

Engl. 2007. Survey of American Literature

3-0-3. Prerequisite: Engl. 1001-2. May be substituted for Engl. 2003.

A study of the development of literature in America, with emphasis on significant figures and their works. Lectures, reports, papers, quizzes.

Engl. 2010. Creative Writing

3-0-3. Prerequisite: Engl. 1001-2.

Study and practice in several forms and methods of creative writing. Recitations, conferences, compositions.

Engl. 2031-2-3. Literature for International Students

5-0-5 each. Sophomore year. Prerequisite: Engl. 1031-2-3. To be taken by foreign students in lieu of Engl. 2001-2-3.

An introduction to American literature, with continued training in writing and speaking American English.

Engl. 2037-8-9. Acting and Producing the Play

0-3-1 each. Prerequisite: consent of the department.

Participation in the DramaTech productions of various kinds of plays, including the presentation of one play before an audience.

Engl. 3006. The English Language

3-0-3. Prerequisite: Engl. 1001-2.

Study of the origin of the English language, its relation to other languages and its differentiation and development into modern English and American.

Engl. 3008. Logic and the Use of Language

3-0-3. Prerequisite: Engl. 1001-2.

Study of principles of logic and semantics and their use in increasing effectiveness of oral and written communication. Analysis of fallacies in the mass media.

Engl. 3015. Public Speaking

3-0-3. Normally taken by juniors and seniors.

Instruction in the basic principles of effective public speaking, with emphasis on practice and criticism. The course is conducted as a laboratory.

Engl. 3018. Persuasive Speaking

3-0-3. Prerequisite: consent of the department.

Principles of argumentation and persuasion. Practice in their application, with the emphasis on issues of current public interest.

Engl. 3019. Oral Communication in Science, Business and Industry

3-0-3. Prerequisite: Engl. 3015.

Study of informative oral communication in science, business and industry. Practice in committee, panel and technical briefing settings. Emphasis on use of audio-visual aids.

Engl. 3023. Written Communication in Science, Business and Industry

3-0-3. Normally taken by juniors and seniors.

Practice in application of principles of effective written communication to important types of professional writing—reports, letters, memoranda. Case method of instruction and individual projects.

Engl. 3024. Advanced Writing

3-0-3. Prerequisite: Engl. 1001-2.

Intensive practice in composition at an advanced level in informative, argumentative and persuasive forms. Discussion of principles and theory of composing. Analysis of appropriate models.

Engl. 3037-8-9. Acting and Producing the Play

0-3-1 each. Prerequisite: consent of the department.

See Engl. 2037-8-9.

Engl. 3041. Writers in the Age of Galileo

3-0-3. Prerequisite: Engl. 1001-2.

Study of works of three of the following: Donne, Bacon, Jonson, Milton, Defoe. Emphasis on their reflection of social, scientific, philosophical attitudes of the age.

Engl. 3042. Writers in the Age of Newton

3-0-3. Prerequisite: Engl. 1001-2.

Study of the works of three of the following: Swift, Fielding, Thoreau, Wordsworth, Keats. Emphasis on their reflection of social, scientific, philosophical attitudes of the age.

Engl. 3043. Writers in the Age of Darwin

3-0-3. Prerequisite: Engl. 1001-2.

Study of works of three of the following: Carlyle, Melville, Arnold, Tennyson, Twain. Emphasis on their reflection of social, scientific, philosophical attitudes of the age.

Engl. 3044. Writers in the Age of Freud and Einstein

3-0-3. Prerequisite: Engl. 1001-2.

Study of works of three of the following: James, Yeats, Shaw, Lawrence, Eliot. Emphasis

on their reflection of social, scientific, philosophical attitudes of the age.

Engl. 3051. Chaucer I

3-0-3. Prerequisite: Engl. 1001-2.

Introduction to the poetry of Chaucer in Middle English. Major emphasis on the study of *The Canterbury Tales*.

Engl. 3052. Shakespeare

3-0-3. Prerequisite: Engl. 1001-2.

A brief statement of the life and times of Shakespeare and a careful study of certain of his principal works. Lectures, reports, papers, quizzes.

Engl. 3056. Joyce

3-0-3. Prerequisite: Engl. 1001-2.

A study of the works of James Joyce, with particular emphasis on Joycean techniques of fiction as developed in *Ulysses* and other selected works.

Engl. 3058. Contemporary Drama

3-0-3. Prerequisite: Engl. 1001-2.

An analytic survey of prominent playwrights and trends in contemporary drama. Lectures, reports, collateral reading, quizzes.

Engl. 3059. Contemporary Fiction

3-0-3. Prerequisite: Engl. 1001-2.

An analytic study of prominent writers and trends in contemporary fiction. Lectures, reports, collateral reading, quizzes.

Engl. 3061. The Literature of the Bible: The Old Testament

3-0-3. Prerequisite: Engl. 1001-2.

Study of selected Old Testament writings, with emphasis on literary quality and intellectual content. Discussion of both in the cultural heritage of the Western world.

Engl. 3062. The Literature of the Bible: The New Testament

3-0-3. Prerequisite: Engl. 1001-2.

Study of selected New Testament writings, with emphasis on literary quality and intellectual content. Discussion of both in the cultural heritage of the Western world.

Engl. 3072. The Civil War in Literature

3-0-3. Prerequisite: Engl. 1001-2.

A study of selected works of literature dealing with the American Civil War, with emphasis on the relations of history and literature.

Engl. 3075. Hemingway

3-0-3. Prerequisite: Engl. 1001-2.

A study of the major novels and selected short stories of Ernest Hemingway, with emphasis on major themes and narrative techniques.

Engl. 3076. Faulkner

3-0-3. Prerequisite: Engl. 1001-2.

A study of selected works of William Faulkner with particular emphasis on major themes and the nature of his narrative art.

Engl. 3081-2-3-4-5-6. Seminars In Literature
3-0-3 each. Prerequisite: consent of the department.

Intensive study of individual writers, movements, periods or themes in literature, with the purpose of developing knowledge in depth, critical independence and expository skill.

Engl. 3141. Fantasy (Lewis and Tolkien)

3-0-3. Prerequisite: Engl. 1001-2.

A study of selected works from C. S. Lewis' *Chronicles of Narnia* and *Space Trilogy* and J. R. R. Tolkien's *Lord of the Rings*, with particular emphasis on structural and thematic development.

Engl. 3161. Science Fiction

3-0-3. Prerequisite: Engl. 1001-2.

Study of selected works of science fiction, with special emphasis on the relationship of their ideas to those of mainstream fiction, science, politics and history. Seminars, reports, papers.

Engl. 3261. Soviet Literature

3-0-3. Prerequisite: Engl. 1001-2.

A study of selected works of Russian literature of the Soviet period, with emphasis on the influences that shape the writers and the responses the writers make to their society.

Engl. 3361. The Athlete In Literature

3-0-3. Prerequisite Engl. 1001-2.

A study of selected works of literature dealing with sport and athletes, with emphasis on how the sporting experience is used in literature.

Engl. 3760. Myth In German Literature

3-0-3. Prerequisite: Engl. 1001-2.

Major German literary works of the classical, romantic and modern periods and their use of myths and archetypes. All readings in English translation.

Engl. 3761. Dostoevsky and Tolstoy In Translation

3-0-3. Prerequisite: Engl. 1001-2.

The short works of Dostoevsky and Tolstoy. Major themes and the nature of their narrative art. Readings in English.

Engl. 3786. The Immigrant Experience

3-0-3. Prerequisite: Engl. 1001-2.

The history and literature of the immigrant, stressing life in the Old World and reasons for emigrating, the passage to America, impressions

of the New World and problems of assimilation. Lectures, reports, papers.

Engl. 4041. Studies In the Novel

3-0-3. Prerequisite: Engl. 1001-2.

Intensive analysis of selected novels, with emphasis on the artistic excellence and significance of the works in the development of modern scientific and philosophical attitudes.

Engl. 4042. Studies In Drama

3-0-3. Prerequisite: Engl. 1001-2.

Intensive analysis of selected plays, with emphasis on the artistic excellence and significance of the works in the development of modern scientific and philosophical attitudes.

Engl. 4043. Studies In Poetry

3-0-3. Prerequisite: Engl. 1001-2.

Intensive analysis of selected poems, with emphasis on the artistic excellence and significance of the works in the development of modern scientific and philosophical attitudes.

Engl. 4044. Studies In the Essay

3-0-3. Prerequisite: Engl. 1001-2.

Intensive analysis of selected essays, with emphasis on the artistic excellence and significance of the works in the development of modern scientific and philosophical attitudes.

Engl. 4051. Chaucer II

3-0-3. Prerequisite: Engl. 3051.

Continuation of Engl. 3051. Major emphasis on the study of *Troilus and Criseyde*.

Engl. 4081-2-3. Seminars In Themes and Problems In Contemporary Literature

3-0-3. Prerequisite: Engl. 1001-2.

Intensive study of works of modern literature which treat the themes of man and himself, man and society, and selected issues of concern.

Engl. 4755. Sex Roles: Their Development and Cultural Influence

3-0-3. Prerequisite: consent of the department.

Psychological principles, legal facts and literary explications are integrated in an examination of the roles of men and women from three time perspectives: historical, current and future. Readings, lectures, discussions and invited panelists will be utilized. Jointly taught by English, psychology and social sciences.

Engl. 4801-11-21. Special Topics

1-0-1. Prerequisite: consent of the department.

Study of special topics of current interest in the humanities.

Engl. 4803-13-23. Special Topics

3-0-3. Prerequisite: consent of the department.

Study of special topics of current interest as reflected in selected literary works.

Engl. 4901-2-3-4. Special Problems

Credit to be arranged. Prerequisite: consent of the department.

Studies in specialized aspects of literature and language selected on basis of current interest.

FRENCH

See Modern Languages.

GEOPHYSICAL SCIENCES

Geo.S. 1000. Introduction to Earth Science

3-0-3.

A survey of planetary science, atmospheric science and oceanography giving general insight into the nature of man's environment.

Geo.S. 2100. General Geology

3-0-3. Corequisite: Chem. 1102 or 1112, Phys. 2121.

Introduction to minerals, rocks and soils. Structure and evolution of the earth's surface features, crust and interior.

Geo.S. 2102. General Geology Laboratory

0-3-1. Corequisite: Geo.S. 2100.

Exercises on minerals, rocks, topographic maps and geologic maps.

Geo.S. 2300. Survey of Oceanography

3-0-3.

Selected topics from geological, physical, chemical and biological oceanography, marine technology, marine environment, resources from the sea. Relationships between man and the sea.

Geo.S. 3000. Earth Resources

3-0-3. Prerequisite: Geo.S. 2100.

A study of Earth's physical resources—fresh water, land (soils), minerals and fuels—emphasizing the geologic origin, geographic distribution and future availability of the resources.

Geo.S. 3100. History of the Earth

3-3-4. Prerequisite: Geo.S. 2100, Geo.S. 2102.

Antiquity of Earth. Interacting evolution of biosphere, atmosphere and lithosphere on the primitive Earth. Phanerozoic history and life. Evolution of living systems. Rise of man.

Geo.S. 3400. Mineralogy

3-3-4. Prerequisite: Geo.S. 2102 or consent of department.

Crystal bonding and symmetry, crystal structure and crystal chemistry, application to geologically important minerals. Laboratory devoted to crystallography, hand specimen identification, X-ray diffraction.

Geo.S. 3410. Optical Mineralogy

1-3-2. Prerequisite: Geo. S. 3400.

A brief introduction to the use of the polarizing microscope for the identification and study of rocks and minerals.

Geo.S. 3500. The Earth-Moon System

3-0-3. Prerequisite: Phys. 2123.

Physical interactions of earth, moon and sun. Structure and evolution of the earth-moon system. Introduction to lunar geology.

Geo.S. 4100. The Influence of Man's Activities on the Global Environment

3-3-4. Prerequisite: Geo.S. 2100.

The interacting equilibrium of atmosphere, hydrosphere, biosphere and lithosphere. The interfering effects of man's activities on the cyclic equilibria on the earth.

Geo.S. 4150. Petrology of the Sedimentary Rocks

2-3-3. Prerequisite: Geo.S. 3410.

Texture, composition and structure of sediments and sedimentary rocks, sedimentary processes (hydraulics and aqueous geochemistry), analysis of sedimentary environments.

Geo.S. 4200. Structural Geology

3-3-4. Prerequisite: Geo.S. 2102.

Structures produced by rock deformation during tectonic and metamorphic activity. Primary structural features. The laboratory will include several field trips.

Geo.S. 4250. Engineering Geology

3-3-4. Prerequisite: Geo.S. 2100.

Applications of geological science to problems of civil engineering.

Geo.S. 4300. Introduction to Physical and Chemical Oceanography

3-0-3. Prerequisite: Geo.S. 2100 or consent of department.

Ocean geometry, physical properties of sea water, water movements and energy fluxes, sediments, marine geochemistry, marine geophysics and tectonics, ocean history.

Geo.S. 4301. Applied Oceanography

6-4-5 (six weeks). Prerequisites: Geo.S. 2100 or consent of department.

The aspects of physical, chemical and biological sciences which are marine-oriented as applied to specific problems in the ocean and its environs. Collection and interpretation of field data stressed, utilizing vessels and equipment of the Skidaway Institute of Oceanography.

Geo.S. 4400. Petrology of Igneous and Metamorphic Rocks.

3-3-4. Prerequisite: Geo.S. 3410.

Composition, texture, and structure of igneous and metamorphic rocks. Physical, chemical, and geologic conditions controlling metamorphism and igneous activity. Laboratory involves microscopy.

Geo.S. 4500. Introduction to Geophysics

3-0-3. Prerequisite: Geo.S. 2100.

General survey of terrestrial geophysics. Topics discussed include the earth's seismicity, internal structure, shape, gravity, magnetic field, paleomagnetism, heat flow and global tectonics.

Geo.S. 4550. Applied Geophysics

3-3-4. Prerequisite: Geo.S. 2100, Phys. 2143.

Theory of electrical, magnetic, gravity, seismic refraction and reflection exploration methods. The laboratory provides exercises in instrumentation and data interpretation.

Geo.S. 4600. Introduction to Geochemistry

3-3-4. Prerequisite: Chem. 2113.

Distribution and behavior of the chemical elements and natural compounds in the earth, its waters, and its atmosphere. Application of chemical principles to geologic processes.

Geo.S. 4650. Introduction to Atmospheric Sciences

3-0-3. Prerequisite: Chem. 1102, Math, 2309, Phys. 2123, thermodynamics.

Introduction to atmospheric physics, chemistry and dynamics, with emphasis on the interdisciplinary nature of atmospheric science, and man's interaction with the environment.

Geo.S. 4800. Special Topics
0-6-2.

Geo.S. 4801. Special Topics
1-0-1.

Geo.S. 4802. Special Topics
2-0-2.

Geo.S. 4803. Special Topics
3-0-3.

Geo.S. 4804. Special Topics
4-0-4.

Geo.S. 4805. Special Topics
5-0-5.

Geo.S. 4900. Special Problems.

Geo.S. 6050. Geophysics I—Seismology and Heat Flow

3-3-4. Prerequisite: consent of department.

An intense theoretical survey of terrestrial geophysics. Topics include seismology, wave motion, structure of earth's interior and heat flow. Laboratory stresses directed projects.

Geo.S. 6051. Geophysics II—Gravity

3-3-4. Prerequisite: consent of department.

An intense theoretical survey of terrestrial geophysics. Topics include potential theory, shape of the earth and physical geodesy.

Geo.S. 6052. Geophysics III—Geomagnetism and Paleomagnetism

3-0-3. Prerequisite: Geo.S. 6051 or consent of department.

Topics include magnetohydrodynamics, origin and description of Earth's magnetic field, rock magnetism, remanent magnetism, geo-physical evidence for global tectonics and tectonic mechanisms.

Geo.S. 6100. Clay Mineralogy

3-0-3. Prerequisite: consent of department.

The composition and structure of clay minerals, physical and chemical properties, X-ray identification, geologic distribution and significance, origin.

Geo.S. 6110. Advanced Clay Mineralogy

2-3-3. Prerequisite: Geo.S. 6100

Clay-Water relations; cation exchange; effects of crystal structure and composition on physical and chemical properties, X-ray, electron microscope and other techniques.

Geo.S. 6150. Sedimentary Geology

3-3-4. Prerequisite: Geo.S. 3410.

Composition, texture and structure of sediments and sedimentary rocks, sedimentary processes, diagenesis, environments of deposition, stratigraphy of sedimentary rocks.

Geo.S. 6160. Stratigraphy and Sedimentation
3-0-3. Prerequisite: Geo.S. 6150.

Continuation of Geo.S. 6150 with emphasis on sedimentary environments, recent and ancient. Principles of correlation, stratigraphic mapping and stratigraphic analysis.

Geo.S. 6180. Geology of Ground Water

3-0-3. Prerequisite: Geo.S. 2100.

Relates ground water quality and availability to the geology of specific areas.

Geo.S. 6210. Global Tectonics

3-0-3. Prerequisite: Geo.S. 4200.

Geological aspects of the new global tectonics.

Geo.S. 6220. Advanced Structural Geology

3-0-3. Prerequisite: Geo.S. 4200.

Geo.S. 6250. Advanced Engineering Geology

3-0-3. Prerequisite: Geo.S. 4200 or consent of instructor.

Application of geosciences to the examination and solution of problems in civil engineering.

Geo.S. 6300. Principles of Physical Oceanography

3-0-3. Prerequisite: consent of department.

Temperature, salinity and density in the oceans. Dynamics of ocean currents. Theory of ocean waves. Selected topics with application to coastal and estuarine circulation.

Text: at the level of Neumann and Pierson, *Principles of Physical Oceanography*.

Geo.S. 6310. Principles of Chemical Oceanography

3-0-3. Prerequisite: Chem. 3412, Geo.S. 4300 or consent of department.

Brief overview of the chemistry of sea water and marine sediments. Detailed discussion of selected topics.

Geo.S. 6400. Igneous Petrology

3-4-4. Prerequisite: Chem. 2113, Geo.S. 4400, Geo.S. 6425.

Microscopic study, classification, physical chemistry, and evolution of igneous rocks.

Geo.S. 6425. Geologic Phase Diagrams

3-0-3. Prerequisite: Chem. 2113, Geo.S. 4400, 4600, or consent of department.

Practical application of available phase diagrams to problems in metamorphic and igneous petrology. Phase rule is used extensively.

Geo.S. 6450. Metamorphic Petrology

3-4-4. Prerequisite: Chem. 2113, Geo.S. 4400, Geo.S. 6425.

Study and classification of chemical and physical changes induced in rocks upon metamorphism. Microscopic laboratory study.

Geo.S. 6510. Analytical Methods in Geophysics I

3-3-4. Prerequisite: Geo.S. 6050, 6051.

Theory and practice in the application of numerical analysis methods to geophysical data. Topics include information theory in seismology and harmonic analysis of potential data.

Geo.S. 6520. Analytical Methods in Geophysics II

3-3-4. Prerequisite: consent of instructor.

Hankel transforms and applications, electrical soundings. Propagation of plane waves in non-homogeneous media, the W.K.B.J. approxima-

tion, magneto-telluric soundings. Radiation of a dipole over a layered conducting half space, electromagnetic soundings.

Geo.S. 6550. Observational Seismology

3-3-4. Prerequisite: Geo.S. 4500.

A study of the nature of earthquake motion and the damage it causes. The laboratory provides exercises in the interpretation of seismograms.

Geo.S. 6560. Theoretical Seismology

3-3-4. Prerequisites: Math. 4320, 4581, 4582, Geo.S. 6050, 6550.

Theory of elastic wave propagation in the earth. Topics include reflection of waves, surface waves and Cagniard theory of body waves.

Geo.S. 6600. Aqueous Geochemistry

3-0-3. Prerequisite: Chem. 3412, Geo.S. 2100 or consent of department.

Reactions of minerals in waters on or near the surface of the Earth.

Geo.S. 6610. Organic Geochemistry

3-0-3. Prerequisite: Chem. 3313 or consent of department.

Geochemistry of organic substances. Diagenesis of organic matter. Chemical fossils. Chemical evolution on the primitive Earth.

Geo.S. 6620. Nuclear Geochemistry

3-0-3. Prerequisite: Phys. 2123, Geo.S. 3400.

Nuclear reactions and radioactive decay in nature. Geochemistry of radionuclides. Age measurements based on radioactive decay. Abundance variations of radiogenic and cosmogenic stable nuclides.

Geo.S. 6625. Stable Isotope Geochemistry

2-0-2. Prerequisite: Chem. 2113, Geo.S. 3400.

Variations in isotopic composition of the elements owing to isotope effects in natural physical and chemical processes. Application of isotope ratio measurement to geochemistry, hydrology, oceanography and paleoclimatology.

Geo.S. 6750. Introductory Diffraction Studies

2-6-4. Prerequisite: consent of department.

Introductory theory and practice of the most widely applicable X-ray and neutron diffraction techniques. Identification, lattice parameters, textures, line breadth and crystal orientation. Cross-listed with Phys. 4266.

Geo.S. 6764. Ocean Acoustics

3-0-3. Prerequisites: Math. 4582, 4321. Recommended: Geo.S. 4300, A.E. 6760.

Propagation of sound waves in the ocean. Topics selected from stress-strain relationships, asymptotic ray theory, propagation in shallow

and deep water, irregularities of the media and boundaries, sonar arrays. Cross-listed with A.E. 6764, M.E. 6764, E.S.M. 6764.

Geo.S. 6791. Atmospheric Turbulence

3-0-3. Prerequisite: Geo.S. 4650, fluid dynamics.

Introduction to turbulence, turbulent transport of momentum and heat, sources of turbulence in the atmosphere, the dynamics of turbulence in the atmosphere, the dynamics of turbulence, statistical description, correlation functions and the spectral dynamics of turbulence.

Geo.S. 6792. Air Pollution Meteorology

3-0-3. Prerequisite: Geo.S. 4650 or concurrently.

Vertical temperature and wind structure, topographic effects, natural removal processes, atmospheric dispersion of stack effluents, air pollution climatology, meteorological management of air pollution.

Geo.S. 6793. Atmospheric Boundary Layer

3-0-3. Prerequisite: Geo.S. 6910 or Geo.S. 6912.

Structure and aerodynamics of atmospheric boundary layer, turbulent transport of contaminants in the environment, stratified and disturbed atmospheric boundary layer, free convection layer, current problems.

Geo.S. 6910. Dynamic Meteorology I

3-0-3. Prerequisite: Geo.S. 4650, fluid dynamics.

Scale analysis, equations of motion, equilibrium motion in the atmosphere; circulation, vorticity and divergence theorems; atmospheric waves; hydrodynamic and baroclinic instability; frontal systems; global circulation.

Geo.S. 6911. Dynamic Meteorology II

1-3-2. Prerequisite: Geo.S. 4650, fluid dynamics.

Meteorological instrumentation and measurement techniques. Thermodynamics and stability calculation. Weather map and chart analysis. Cross section and trajectory analysis. Advection of pressure and temperature patterns.

Geo.S. 6915. Synoptic Meteorology

3-0-3. Prerequisite: Geo.S. 6910.

Terrestrial or planetary winds, cyclones and anticyclones, the general circulation of the atmosphere, air masses and fronts, tropical cyclones, hurricanes, weather analysis and interpretation.

Geo.S. 6920. Atmospheric Chemistry I

3-0-3. Prerequisite: Chem. 3413 or concurrently.

This course will primarily address the chemistry of the natural troposphere. Major topics will include: physical characteristics, chemical composition, physical and chemical transformations and global budgets.

Geo.S. 6921. Atmospheric Chemistry II

1-3-2. Prerequisite: Geo.S. 6920 or concurrently.

This course is designed to introduce the student to modern instrumental techniques used in obtaining basic information about the chemical properties of the atmosphere.

Geo.S. 6922. Chemistry and Physics of Atmosphere Aerosols

3-0-3. Prerequisites: Geo.S. 6920 or consent of school.

Chemical and physical properties of natural and anthropogenic atmospheric aerosols. Formation and removal mechanisms involved in various atmospheric sources, sinks and transformation processes.

Geo.S. 6927. Photokinetics and Spectroscopy

3-0-3. Prerequisite Geo.S. 6920 or equivalent kinetics courses.

This course will examine the spectroscopy of atomic and molecular species as well as the photodynamics and kinetics resulting from photofragmentation processes.

Geo.S. 6930. Physical Meteorology I

3-0-3. Prerequisite: Math. 2309, thermodynamics.

Physical processes in the atmosphere. Effects of atmospheric composition and structure on solar and terrestrial radiation; physics of clouds, precipitation and thunderstorms.

Geo.S. 6931. Physical Meteorology II

1-3-2. Prerequisite: Geo.S. 6930.

Laboratory course in atmospheric physics. Experiments with state-of-the-art instrumentation for observing and measuring physical properties of atmospheric radiation, aerosols, clouds and precipitation.

Geo.S. 6932. Meteorology for Solar and Wind Energy

2-3-3. Prerequisite: Geo.S. 4650 or concurrently.

Solar radiation instruments, measurement and calibration techniques. Atmospheric attenuation, effects of clouds and turbidity. Meteorological factors of wind energy system design, performance evaluation and siting.

Geo.S. 6933. Precipitation Processes

3-0-3. Prerequisite: Geo.S. 6911 or 6931.

Nucleation and phase changes in the atmosphere, precipitation processes, cloud electrification, artificial modification, application of radar to precipitation.

Geo.S. 6934. Atmospheric Optics and Radiation Transfer

3-0-3. Prerequisite: Geo.S. 6930.

Quantitative treatment of radiative transfer in

the atmosphere; absorption and scattering by atmospheric molecules and particulates; atmospheric visibility and optical effects.

Geo.S. 6940. Introduction to Climate

3-0-3. Prerequisites: Geo.S. 6910, 6920, 6930.

Physical principles underlying the variations and changes in climate; review of past climatic fluctuations; climate feedback mechanisms; theories of climate changes; man's impact on climate.

Geo.S. 6941. Atmospheric Modeling

3-0-3. Prerequisites: Geo.S. 6910, 6920 and 6930, Math 4643 or consent of school.

Application of modern numerical methods to the prediction of atmosphere motions, chemical and physical compositions: initialization and assimilation methods; filtering, verification and testing.

Geo.S. 7000. Master's Thesis

Geo.S. 7911. Upper Atmospheric Dynamics

3-0-3. Prerequisite: Geo.S. 6910.

The dynamics of the neutral atmosphere in the stratosphere, mesosphere, and lower thermosphere—prevailing winds, jet streams, waves, tides, and turbulence; winter stratwarms, coupling mechanisms.

Geo.S. 7999. Preparation for the Comprehensive Examination

Credit TBA.

Geo.S. 8000. Geophysical Sciences Seminar

1-0-0

Geo.S. 8011-2-3. Seminar

1-0-1 each.

A forum for graduate students in geophysical sciences to present and discuss topics related to their research interests.

Geo.S. 8101-2-3. Special Topics

2-0-2, 2-0-2, 3-0-3.

Geo.S. 8111. Special Topics

1-0-1.

Geo.S. 8112. Special Topics

2-0-2.

Geo.S. 8113. Special Topics

3-0-3.

Geo.S. 8114. Special Topics

4-0-4.

Geo.S. 8115. Special Topics

5-0-5.

Geo.S. 8500-1-2. Special Problems

Credit to be arranged.

Geo.S. 8999. Preparation for Doctoral Dissertation.

Credit TBA.

Geo.S. 9000. Doctoral Thesis

GERMAN

See Modern Languages.

HEALTH SYSTEMS

H.S. 1000. Overview of Health Systems

1-0-1. Prerequisite: freshmen and sophomores only.

A career-oriented description of the interdisciplinary area known as health systems and an orientation to curriculum and course alternatives. Insights into the analysis and planning of health care delivery.

H.S. 2011. The Health Field

3-0-3. Prerequisite: none.

History of hospitals and medicine, the nature, problems and costs of modern health care institutions, proposed improvements and the role of health systems specialists.

H.S. 3011. Hospital Functions

3-0-3. Prerequisite: H.S. 2011.

Internal structure, functions and management problems of hospitals, including departmental interactions, hospital and medical terminology, process flows of materials, supplies, personnel, patients, paperwork and information.

H.S. 3021. Nonhospital Components

3-0-3. Prerequisite: H.S. 2011.

Delivery of medical care including solo, group, prepaid group and emergency services. Health resource planning, private and public finance, health care policy and the role of government.

H.S. 3115. Management Engineering I

3-3-4. Corequisite: H.S. 3011, I.Sy.E. 3028.

Work simplification, process charting, job analysis and evaluation, merit rating and suggestion plans in hospitals. Work measurement principles and practice, predetermined motion-times, work sampling, standard data and incentive plans.

H.S. 3116. Management Engineering II

3-0-3. Prerequisite: H.S. 3115.

Hospital applications of work measurement to

output prediction, crew sizing and work distribution. Manpower and work scheduling, staffing methodologies and cyclical planning. Labor performance control and productivity measurements.

H.S. 3117. Management Engineering III
3-0-3. Prerequisite: H.S. 3115 and FORTRAN programming.

Process planning and control in hospitals. Forecasting, materials management, inventory, production and quality control, queueing analysis and simulation.

H.S. 3118. Management Engineering IV
2-3-3. Prerequisite: E. Gr. 1170, H.S. 3115.

Functional programming, space utilization and facility planning within the hospital. Proximity analysis, layout techniques, materials handling, automation and equipment selection. Critical path methods and interfaces with architecture and construction.

H.S. 3211. Data Processing
3-0-3. Prerequisite: H.S. 3011, Mgt. 3700 and FORTRAN programming.

Hospital and medical information systems, data collection, storage, processing and reporting, file design, record structure, processing requirements, controls, report formats, medical records and statistical audits.

H.S. 3332. Health Care Cost Analysis
3-0-3. Prerequisite: Econ. 2000, H.S. 3011, Mgt. 3700.

Microeconomic analysis of health care delivery, hospital cost finding and cost analysis, evaluating financial alternatives, budget development, pricing policy, rate setting, reimbursement formulas and cost containment.

H.S. 3341. Health Systems Planning
3-0-3. Prerequisite: H.S. 2011.

The systems approach to health planning, policy and program decisions, functional systems specifications, recycling for compromise, systems integration, facility and manpower requirements.

H.S. 3351. Projects and Reports
3-0-3. Prerequisite: Engl. 3023, H.S. 3011, 3021.

Methods and techniques of proposing, planning, conducting and reporting field studies, experiments and projects in health systems. Methodological preparations for externships or special problems.

H.S. 3780. Introduction to Urban Engineering
3-0-3. Normally taken by juniors.

A survey of the current status of scientific and technical contributions to urban socio-economic

problems. Opportunities for increased participation by engineering and related disciplines. Cross-listed with other participating schools.

H.S. 3971-2-3. Special Problems

Credit to be arranged. Prerequisite: prior arrangements with school.

Individual student projects that apply systems techniques to health care management problems with emphasis upon student initiative, methodology, problem solution and written report.

H.S. 4021. Community Health Problems
3-0-3. Prerequisite: H.S. 3011, 3021.

Problems of urban and rural communities and planning for health care needs, community structure and decision making, accessibility and acceptability, planner-community interactions within a systems context.

H.S. 4351. Case Studies

3-0-3. Prerequisite: H.S. seniors only.

Applications of health systems techniques using examples drawn from previous student projects and from professional practice reported in the literature.

H.S. 4570. Field Training Proposal

0-3-1. Prerequisite: H.S. 3351. Open to H.S. students only.

Preparations for field training. Project adviser selection and site assignment, arrangements with site organization, detailed project planning, formal project proposal.

H.S. 4571-2-3. Senior Externship
0-12-4 each. Prerequisite: H.S. 3116-7-8, 3211, 4570. Open to H.S. students only.

Field training for individual students in actual health care institutions, health service organizations or health planning agencies. Major project formal written report and oral presentation. Normally full time for one quarter.

H.S. 4692-3. Seminars

1-0-1 each. Normally taken by seniors.

Guest speakers, discussions of health issues, problems and solutions, field training experiences and employment opportunities.

H.S. 4765. Hospital Management Systems
3-0-3. Normally taken by I.Sy.E. seniors.

Introduction to the health field and to health systems. Applications of industrial engineering principles and techniques to the improvement of hospital management systems.

H.S. 4861-2-3. Health Systems Topics

3-0-3 each. Prerequisite: prior arrangements with school.

Provides formal coursework on special topics not included in regular health systems courses.

H.S. 6001. Introduction to Health Systems
3-0-3. Normally taken by graduate students.

Description of the health care system and its interactive resource components, with emphasis upon accessibility, availability, distribution and cost. Health systems inputs, processes and outputs.

H.S. 6231. Project Management

3-0-3. Prerequisite: H.S. 6001.

Principles and techniques of managing a health systems service program; project planning, direction and control; dealing with environmental subtleties; management reporting and project implementation.

H.S. 6331. Health Systems Analysis I

3-0-3. Prerequisite: H.S. 3115, 6001, I.Sy.E. 6739 and FORTRAN programming.

Methods and techniques of hospital management engineering. Forecasting, inventory control, quality control, queueing analysis and simulation are covered and computer software is utilized.

H.S. 6332. Health Systems Analysis II

3-0-3. Prerequisite: Econ. 6000, H.S. 6001.

Applications of economic analysis to resource allocation in health care delivery. Health care finance and factors involved in cost containment programs.

H.S. 6333. Health Systems Analysis III

3-0-3. Prerequisite: H.S. 6331, I.Sy.E. 6734.

Advanced health systems analysis, emphasizing total-project orientation. Applications of management engineering, statistics, operations research and other quantitative methods within a systems context.

H.S. 6340. Health Planning Techniques

3-0-3. Prerequisite: H.S. 6001, I.Sy.E. 6739.

Methods of group-consensus formation, goal setting and health needs assessment. Coverage includes Delphi and nominal group processes, patient-origin studies, accessibility analysis and decision procedures.

H.S. 6341. Health Systems Planning

3-0-3. Prerequisite: Econ. 6000, H.S. 6340, I.Sy.E. 6734.

Community health planning, facility master planning, health care requirements analysis, systems integration, financial planning and life-cycle costs.

H.S. 6342. Community Health Systems

3-0-3. Prerequisite: H.S. 6340.

Planning for health care needs of a community as a system. Analysis of community structure, decision-making, planner-community interactions and accessibility barriers to services.

H.S. 6351. Research and Evaluation Methods
3-0-3. Corequisite: I.Sy.E. 6739.

Principles and techniques of planning, proposing, conducting, evaluating and reporting research projects. Elements of the scientific method. Critical reviews of theses, research reports and publications.

H.S. 6570. Field Training Proposal

0-3-1. Prerequisite: H.S. 6001, 6351. Open to H.S. students only.

Preparations for field training. Project adviser selection and site assignment, arrangements for data sources, detailed project planning, formal project proposal.

H.S. 6571-2-3-4-5-6. Graduate Field Training

0-3-1 through 0-18-6. Prerequisite: H.S. 6331 or 6340, 6570. Open to H.S. students only.

Field training for individual graduate students in relation to health care institutions, health service organizations or health planning agencies. Graduate project, formal written report and oral presentation. Normally part time over two or three quarters.

H.S. 6765. Case Studies

3-0-3. Prerequisite: H.S. 6001, I.Sy.E. 6734.

Applications of hospital management engineering and health systems planning techniques using examples drawn from professional practice and research reported in the literature.

H.S. 7000. Master's Thesis

Prerequisite: prior arrangements with school.

H.S. 7765. Projects.

1-6-3. Prerequisite: prior arrangements with school.

Research projects addressed at real life problems confronting operational health care institutions and employing modern principles and approaches of health systems analysis. Project report.

H.S. 8092-3. Graduate Seminars

1-0-1 each. Normally taken by graduate students.

Guest speakers, discussions of health issues, problems and solutions, field training experiences and employment opportunities.

H.S. 8161-2-3-4. Topics in Health Systems

3-0-3 each. Prerequisite: prior arrangements with school.

Provides formal coursework on special topics not included in regular health systems graduate courses.

H.S. 8261-2-3-4. Special Topics

1-0-1 through 4-0-4. Prerequisite: prior arrangements with school.

Special or experimental offerings of topical coverage not included in regular health systems graduate courses.

H.S. 8971-2-3-4. Special Problems

Credit to be arranged. Prerequisite: prior arrangements with school.

Individual student projects that apply systems techniques to health care management and planning problems with emphasis upon student initiative, methodology, problem solution and written report.

HISTORY

See Social Sciences.

INDUSTRIAL DESIGN

See Architecture.

INDUSTRIAL AND SYSTEMS ENGINEERING

I.Sy.E. 1010. Basic Concepts in Industrial and Systems Engineering

2-3-3. Available to freshmen only.

Introduction to types of problems concerning industrial and systems engineers. Students develop solutions which are compared to typical analytical solution techniques encountered in I.Sy.E. practice.

I.Sy.E. 3010. Man-Machine Systems

3-0-3.

Introduction to methods for analysis and design of man-machine systems. Stresses quantitative techniques in analysis of work center design and work systems design.

I.Sy.E. 3014. Systems and Productivity

3-0-3. Prerequisite: I.Sy.E. 3010, Psy. 4410.

Human contributions to productivity and interaction of technical advances with human performance. Examination of impact of individual needs, leadership styles and organizational design on productivity.

I.Sy.E. 3025. Engineering Economy

3-0-3. Corequisite: Mgt. 3700.

Methods of economic analysis in engineering including decision problems, value measurement, interest relationships, criteria for decisions under certainty, risk and uncertainty.

I.Sy.E. 3027. Applications of Probability

3-0-3. Prerequisite: Math. 1309.

Introduction to probability, emphasizing applications in science and engineering. Topics include probability concepts, random variables, discrete and continuous distributions.

I.Sy.E. 3028. Engineering Statistics I

3-0-3. Prerequisite: I.Sy.E. 3027 for I.Sy.E. students.

Introduction to statistical methodology, emphasizing applications in science and engineering. Topics include estimation, hypothesis testing and process control.

I.Sy.E. 3029. Engineering Statistics II

3-0-3. Prerequisite: I.Sy.E. 3028 or equivalent.

Introduction to analysis of planned and unplanned experiments. Topics include regression and analysis of variance with applications to problems in engineering and science.

I.Sy.E. 3100. The Professional Practice of Industrial and Systems Engineering

0-3-1. Prerequisite: junior standing.

A laboratory seminar wherein students meet industrial and systems engineering practitioners to discuss their current work problems and career progression.

I.Sy.E. 3105. Organizational Structures

3-0-3.

The organizational elements, activities and structures within which an industrial engineer functions.

I.Sy.E. 3113. Physiological and Biomechanical Analysis of Work

3-0-3. Prerequisite: I.Sy.E. 3010.

Techniques of data collection and analysis for effective man-power oriented tool and work place design.

I.Sy.E. 3115. Industrial and Systems Engineering Measurements

3-0-3. Corequisite: I.Sy.E. 3028, 3105, or consent of school.

The techniques used by industrial engineers measure the physical characteristics of systems, human activities and costs.

I.Sy.E. 3131. Operations Research I

3-0-3. Prerequisite: Math. 2307 or Math. 2010.

Models and methods of operations research in solving engineering and management problems. Includes linear models, linear programming, duality, post optimality and network analysis.

I.Sy.E. 3132. Operations Research II

3-0-3. Prerequisite: Math. 2307.

Nonlinear and stochastic models and methods in operations research to solve engineering and

management problems. Includes application of optimality conditions, search concepts, branch-and-bound, dynamic programming, Markov chains and decision-making under risk.

I.Sy.E. 3260. Introduction to Systems Engineering

3-0-3. Prerequisite: Math. 3709.

Introduction to classical/modern system analysis and feedback dynamics as applied to industrial engineering problems. Transfer functions, state models, transient and steady state behavior, stability and compensation.

I.Sy.E. 3749. Elementary Quality Control

3-0-3. Not available to I.Sy.E. students or students with credit for I.Sy.E. 4039.

Introduction to industrial quality control using statistical methods. Includes methods of data analysis, sampling and control charts as applied to manufacturing processes.

I.Sy.E. 3780. Introduction to Urban Engineering

3-0-3. Prerequisite: junior standing in engineering or architecture.

Survey of the current status of scientific and technical contributions to urban socio-economic problems, and opportunities for increased participation by engineering and related disciplines.

I.Sy.E. 4000. Introduction to Systems Theory

3-0-3. Prerequisite: consent of school.

The basic classical and modern concepts and tools required for modeling, analysis and synthesis of linear, discrete and continuous, deterministic and dynamic systems.

I.Sy.E. 4005. Nonlinear Programming

3-0-3. Prerequisite: I.Sy.E. 3131 or equivalent.

Solution procedures for nonlinear programs. Unconstrained optimization, gradient and gradient-free methods, constrained optimization, Lagrange multipliers, penalty functions and linear approximation methods.

I.Sy.E. 4006. Integer and Dynamic Programming

3-0-3. Prerequisite: I.Sy.E. 3131 or equivalent.

Optimization by dynamic and integer programming. Decision trees, optimality principle and recursive relationships. Optimization in integer by cutting planes, branch and bound and implicit enumeration.

I.Sy.E. 4022. Job Evaluation and Wage Incentives

3-0-3. Prerequisite: I.Sy.E. 3010.

Study of principles used to establish wage rates and salaries. Emphasizes characteristics and objectives of wage incentive plans and design and analysis of incentive formulas.

I.Sy.E. 4024. Fundamentals of Materials Handling

2-3-3. Prerequisite: I.Sy.E. 3010, 3025.

Development of procedures and techniques for analysis and solution of materials handling problems. Plant trips and laboratories utilized to illustrate modern materials handling methods.

I.Sy.E. 4028. Introduction to Feedback Dynamics

2-3-3.

Examination of feedback processes as causes of dynamic behavior in socioeconomic and managerial systems. Emphasizes feedback loop performance characteristics and computer simulation of multivariate non-linear systems.

I.Sy.E. 4035. Project Management Systems Design

2-3-3. Prerequisite: senior standing or consent of school.

Project planning and control using activity network analysis. Emphasizes network logic, scheduling computations, resource scheduling, time-cost trade off algorithms and multiproject resource allocation.

I.Sy.E. 4039. Quality Control

3-0-3. Prerequisite: I.Sy.E. 3028 or equivalent. Not available to students with credit for I.Sy.E. 3749.

Design of quality control systems. Quantitative techniques for establishing product specifications, process controls, acceptance inspection and other techniques of quality assurance.

I.Sy.E. 4040. Case Problems in Industrial Engineering

3-0-3. Prerequisite: senior standing or consent of school.

Unstructured diverse problems requiring industrial engineering and systems methodology for pragmatic solutions. Problems simulate challenges most likely to be experienced by functioning professional engineers.

I.Sy.E. 4044. Simulation

2-3-3. Prerequisite: I.Sy.E. 3028, I.C.S. 1700.

Discrete simulation methodology emphasizing statistical basis for simulation modeling and experimentation. Overview of computer languages and continuous flow models. Laboratory exercises illustrating model architecture, inference and optimization.

I.Sy.E. 4053. Introduction to Socioeconomic Systems Analysis

3-0-3. Prerequisite: senior standing or consent of school.

Applications of operations research/systems analysis technology and methodology to current

social problems. Topics include human resources development, transportation systems, environmental quality and management of municipalities.

I.Sy.E. 4056. Technological Forecasting
3-0-3. Prerequisite: senior standing or consent of school.

Emphasizes forecasting future trends and specific developments in areas of technology. Develops methodologies for identifying future functional capabilities and needs. Case histories in technological forecasting utilized.

I.Sy.E. 4073. Storage and Distribution Systems Design
3-0-3. Prerequisite: I.Sy.E. 4102.

Fundamentals of designing efficient materials and product distribution systems emphasizing warehouse planning, materials and information flow, equipment selection, building design and location, automated warehousing and transportation.

I.Sy.E. 4090. Legal and Ethical Phases of Engineering
3-0-3. Prerequisite: senior standing or consent of school

Introduces the engineer to the ethical, legal and professional attitudes to be encountered in the future working environment. Includes business, patent and copyright law considerations.

I.Sy.E. 4101. Operations Planning and Scheduling
3-3-4. Prerequisite: I.Sy.E. 3131.

Analytical methods for production and inventory control emphasizing forecasting techniques, inventory models, application of mathematical programming and network models, sequencing and scheduling techniques and line balancing.

I.Sy.E. 4102. Operations and Facilities Design
3-3-4. Prerequisite: I.Sy.E. 3115.

Principles and practices in the design of operations and facilities for a productive system.

I.Sy.E. 4103. Management Information and Control Systems
3-0-3. Prerequisite: I.Sy.E. 4101.

Principles of the analysis and design of management information and control systems—especially those involving electronic data processing.

I.Sy.E. 4104. I.Sy.E. Design I
0-9-3. Prerequisite: I.Sy.E. 4101, 4044, 4102 or 4053. Must be followed by I.Sy.E. 4105 in consecutive quarters.

Senior I.Sy.E. group design project requiring problem definition and analysis, synthesis, specification and installation of a designed solution in off-campus enterprise environments.

ification and installation of a designed solution in off-campus enterprise environments.

I.Sy.E. 4105. I.Sy.E. Design II
0-9-3. Prerequisite: I.Sy.E. 4103, 4104.

Senior continuation of I.Sy.E. group design project sequence (I.Sy.E. 4104) requiring problem definition and analysis, and synthesis, specification, and installation of a designed solution.

I.Sy.E. 4157. Evaluation of Complex Service Systems
3-0-3. Prerequisite: I.Sy.E. 3028 or equivalents.

Design and analysis of evaluation systems, development and measurement of evaluation criteria, classical methods both qualitative and quantitative, and suggested approaches. Case studies.

I.Sy.E. 4176. Quantitative Methods in Facilities Design
3-0-3. Prerequisite: I.Sy.E. 3131, 3132, 4044 and 4102.

Operations research methodologies applied to facilities planning and design problems. Facilities layout and location problems, assembly line balancing, conveyor design and automated warehousing problem.

I.Sy.E. 4725. Engineering Economy
3-0-3. Prerequisite: sophomore standing. Not available to I.Sy.E. students or students with credit for I.Sy.E. 4726.

Fundamental principles and basic techniques of economic analysis of engineering projects including economic measures of effectiveness, time value of money, cost estimation, breakeven and replacement analysis.

I.Sy.E. 4757. Technology Assessment
3-0-3. Prerequisite: junior standing.

Systematic efforts to anticipate impacts on society that may occur when a technology is introduced, extended or modified. Considers concepts, organization and uses of various specific assessment methods.

I.Sy.E. 4765. Industrial Engineering in Hospitals
3-0-3. Prerequisite: senior standing or consent of school.

Study of hospital management systems and means of improvement by application of industrial engineering principles and techniques. Introduction to health systems and survey of medical terminology. Cross-listed as H.S. 4765.

I.Sy.E. 4897-8-9. Special Topics
3-0-3 each. Prerequisite: consent of school.

Courses in special topics of timely interest to the profession conducted by resident or visiting faculty.

I.Sy.E. 4991-2-3. Special Problems

Credit to be arranged. Prerequisite: senior standing in I.Sy.E. and prior faculty topic approval.

A one to three hour credit opportunity to develop initiative and apply fundamental principles by performing semioriginal laboratory or research work in industrial and systems engineering.

I.Sy.E. 4994-5-6. Research and Projects

Credit to be arranged. Prerequisite: senior standing in I.Sy.E. and prior faculty topic approval.

Research or project work in conjunction with faculty investigations, which may result in undergraduate thesis. Limited to six hours for students with less than a 3.0 cumulative point average.

I.Sy.E. 6101. Modern Organizations
3-0-3.

A comprehensive study of the theories of industrial organization with particular emphasis on analyzing, evaluating and integrating organizational activities.

I.Sy.E. 6103. Organizational Decision-Making
3-0-3. Prerequisite: I.Sy.E. 6101, 6734.

A course integrating behavioral findings with mathematical models of the decision process. The major focus is on these processes in organizational settings.

I.Sy.E. 6107. Management of Improvement
3-0-3.

Concepts of the management of improvement endeavors, strategies and tactics for achieving continuous improvement within organizations. Theoretical bases and approaches to encourage innovation are studied.

I.Sy.E. 6211. Analysis and Evaluation of Industrial Projects
3-0-3. Prerequisite: I.Sy.E. 3025 or equivalent.

This course deals with the financial feasibility analysis of new ventures and other industrial projects. Starting with the generation of venture ideas for new ventures, all steps involved in feasibility analysis are covered. The final topic is the preparation of the investment proposal.

I.Sy.E. 6218. Work Systems Design
3-0-3. Prerequisite: consent of school.

Advanced study of the design of work systems with emphasis on the human operator and that role in the work system.

I.Sy.E. 6219. Human Factors Engineering
3-0-3.

Application of information on human capabilities and limitations in the design process. Design problems are used to aid understanding of application of human factors data.

I.Sy.E. 6220. Work Physiology
3-0-3.

An evaluation of the various factors affecting human physical performance in the industrial environment. Topics: anthropometry, biomechanics, energy expenditure, heat stress, fatigue, training, strength.

I.Sy.E. 6221. Man-Machine Control Systems
3-0-3. Prerequisite: consent of school.

An introduction to the application of systems theory and methodology to the analysis and design of man-machine control systems.

I.Sy.E. 6222. Ergonomics Seminar
3-0-3. Prerequisite: I.Sy.E. 6219.

Seminar in the human factors area pertinent to the design of work systems. Topics: shift work, sex difference, aging, rest periods and occupational safety and health.

I.Sy.E. 6225. Advanced Engineering Economy
3-0-3. Prerequisite: I.Sy.E. 3025, 3131.

Advanced engineering economy topics, including measuring economic worth, economic optimization under constraints, analysis of economic risk and uncertainty, foundations of utility theory.

I.Sy.E. 6226. Replacement Analysis
3-0-3. Prerequisite: graduate standing, I.Sy.E. 3025, 6734 or equivalent.

Emphasis on analytical methods utilized to evaluate the economic desirability of replacement and retirement options. Use of asset records and analytical methods for estimating asset service lives.

I.Sy.E. 6301. Quality Control Systems
3-0-3. Prerequisite: I.Sy.E. 4039.

The design of quality control systems for production and service enterprises. Topics include costs of quality, quality control systems design and evaluation of system performance.

I.Sy.E. 6305. Forecasting Systems
3-0-3. Prerequisite: Math. 4241 or equivalent.

Techniques and systems for forecasting time series. Statistical methods for generating short term forecasts, analysis of forecast error and design of forecasting systems.

I.Sy.E. 6306. Inventory Systems
3-0-3. Prerequisite: I.Sy.E. 3027, 3131 or equivalent.

An introductory course in inventory theory. Deterministic lot size models, probabilistic models of continuous and periodic review policies, dynamic models and multiechelon systems.

I.Sy.E. 6307. Scheduling Theory

3-0-3. Prerequisite: I.Sy.E. 6656.

Analysis of sequencing and scheduling activities. Static scheduling problems, dynamic scheduling systems, simulation studies of priority dispatching rules, priority queueing models.

I.Sy.E. 6308. Analysis of Production Operations

3-0-3. Prerequisite: I.Sy.E. 6306, 6669.

Mathematical models for production planning. Applications of mathematical programming, dynamic programming, network theory and heuristic methods to problems of planning production, inventories and capacity.

I.Sy.E. 6400. Design of Experiments

3-0-3. Prerequisite: I.Sy.E. 6739 or equivalent.

Analysis and application of standard experimental designs, including factorials, randomized blocks, latin squares, confounding and fractional replication. Orthogonal polynomials and multiple comparisons are also discussed.

I.Sy.E. 6401. Applied Regression Analysis

3-0-3. Prerequisite: I.Sy.E. 3028 or I.Sy.E. 6739 or equivalent.

Analysis of data from unplanned experiments. Emphasis on the application of statistical principles to empirical model building.

I.Sy.E. 6402. Time Series Analysis

3-0-3. Prerequisite: I.Sy.E. 3029 or equivalent.

Building empirical-stochastic models of the autoregressive moving-average form for stationary and nonstationary phenomena. Topics include identification procedures, parameter estimation, diagnostic checking and model forecasting.

Text: at the level of Box and Jenkins, *Time Series Analysis, Forecasting and Control*.

I.Sy.E. 6404. Nonparametric Statistics

3-0-3. Prerequisite: I.Sy.E. 6739 or equivalent.

Basic concepts and applications of nonparametric statistics. Order statistics, runs, goodness of fit tests, one-sample, two-sample and k-sample tests for location and scale.

I.Sy.E. 6405. Response Surfaces I

3-0-3. Prerequisite: I.Sy.E. 6400.

Introduction to response surface methodology. Topics include canonical analysis, steepest ascent, first and second order response surface designs, concepts of rotatable and uniform precision designs.

Text: at the level of Myers, *Response Surface Methodology*.

I.Sy.E. 6406. Response Surfaces II

3-0-3. Prerequisite: I.Sy.E. 6405.

A continuation of I.Sy.E. 6405. Topics include orthogonal blocking in response surface designs,

alternative design criteria, the mixture problems and current research problems.

Text: at the level of Myers, *Response Surface Methodology*.

I.Sy.E. 6407. Sampling Techniques

3-0-3. Prerequisite: I.Sy.E. 3029 or equivalent.

Survey sampling techniques. Topics include simple random and stratified random sampling, ratio estimation, regression techniques, systematic, cluster and multistage sampling and sources of error.

Text: at the level of Cochran, *Sampling Techniques*, third edition.

I.Sy.E. 6409. Quasi-Experimental Design

3-0-3. Prerequisite: I.Sy.E. 6400.

Design, application, statistical analysis, and critical evaluation of quasi-experiments (i.e., extension of experimental design concepts into field settings that preclude ideal, randomized experiments).

I.Sy.E. 6427. Applied Statistical Decision Theory

3-0-3. Prerequisite: Math. 4241 or equivalent.

An intermediate-level course in statistical decision theory and its application to problems in operations research, industrial and systems engineering.

Text: at the level of Raifa and Schlaifer, *Applied Statistical Decision Theory*.

I.Sy.E. 6515. Analysis of Distribution Systems

3-0-3. Prerequisite: I.Sy.E. 4044, 4101 or equivalent.

Study of the various types of transportation systems available to enterprises for distributive services. Analysis of distribution alternatives stressed, emphasizing design of economic and control systems encountered.

I.Sy.E. 6524. Material Flow Systems

3-0-3. Prerequisite: I.Sy.E. 4101-2 or consent of school.

Methodology useful in analysis and design of in-plant material flow systems and their interfaces with transportation and distribution systems emphasizing quantitative and simulation techniques.

I.Sy.E. 6650. Probabilistic Models in Operations Research

3-0-3. Prerequisite: Math. 4221 or equivalent.

Applications of probability and stochastic processes in operations research. Focusing on economic decision-making and optimization in Poisson birth-and-death and Markov processes.

I.Sy.E. 6656. Queueing Theory

3-0-3. Prerequisite: Math. 4221 or equivalent.

Topics include a probability review, properties

of the Poisson and exponential distributions, one-dimensional and multidimensional birth-and-death queueing models.

Text: at the level of White, et al., *Analysis of Queueing Systems*.

I.Sy.E. 6669. Linear Deterministic Models in Operations Research

4-0-4. Prerequisite: I.Sy.E. 3131 or equivalent.

The optimization of linear models including the revised, dual, and primaldual simplex methods, duality theorems, decomposition, cutting plane algorithms, some network algorithms.

I.Sy.E. 6670. Nonlinear Deterministic Models in Operations Research

4-0-4. Prerequisite: I.Sy.E. 3131 or equivalent.

Algorithms for solving nonlinear constrained and unconstrained problems at the level of Aoki, *Introduction to Optimization Techniques*. Quadratic programming, dynamic programming and enumerative methods.

I.Sy.E. 6679. Computational Methods in Optimization

3-0-3. Prerequisite: I.Sy.E. 6669 and knowledge of FORTRAN.

Strategies and techniques for translating optimization theory into effective computational software. Emphasis on applications in linear, nonlinear and integer programming, networks and graphs.

I.Sy.E. 6680. Location Theory

3-0-3. Prerequisite: I.Sy.E. 6669 or consent of school.

Applications of optimization theory to the location of facilities. Area and point location problems in discrete and continuous space are examined. Private and public sector applications are considered.

I.Sy.E. 6734. Methods of Operations Research

5-0-5. Prerequisite: Math. 2309. Corequisite: statistics.

An introduction to the methods for the analytical formulation and solution of decision problems. Mathematical methods of optimization and classical operations research models are introduced. Not available for degree credit to I.Sy.E. students.

I.Sy.E. 6739. Experimental Statistics

4-0-4. Prerequisite: Math. 2308.

An introduction to the application of statistics. Topics include probability concepts, sampling distributions, point and interval estimation, hypothesis testing, multiple linear regression, analysis of variance. Not available for degree credit to I.Sy.E. students.

Text: at the level of Hines and Montgomery, *Probability and Statistics*.

I.Sy.E. 6751-2. Complex Systems Design

2-4-3 each. Prerequisite: graduate standing.

This two-quarter sequence permits students from all schools to meet, form an interdisciplinary team and carry out preliminary design of a significant complex system.

I.Sy.E. 6765. Analysis of Health Care Delivery Systems

3-0-3. Prerequisite: I.Sy.E. 4765, 6734 or consent of school.

Survey of management and research problems occurring in health-care delivery complexes together with critical analysis of technical studies employing operations research and systems engineering methodologies. Cross-listed as H.S. 6765.

I.Sy.E. 6800. Systems Research and Application I

3-0-3. Prerequisite: I.Sy.E. 4000 or consent of school.

Individual work and study of cases reflecting the application of the systems engineering process to the modeling, analysis, design and implementation of various classes of man-machine, socioeconomic and ecological systems.

I.Sy.E. 6801. Systems Research and Applications II

3-0-3. Prerequisite: I.Sy.E. 6800.

An interdisciplinary class project requiring small team organization and directed at the application of the systems engineering process to a single problem area.

I.Sy.E. 6802. Advanced Systems Theory I

3-0-3. Prerequisite: I.Sy.E. 4000.

A course extending linear, continuous, deterministic methodologies to nonlinear, discrete and stochastic dynamic system representations and analysis.

I.Sy.E. 6805. Reliability Engineering

3-0-3. Prerequisite: Math. 4215, 4221 or equivalent.

Reliability prediction for nonmaintained systems, availability prediction for maintained systems, life demonstration test design, the concept of system effectiveness.

I.Sy.E. 6806. Introduction to Feedback Dynamics

3-0-3.

Philosophy of feedback causality. Methodology for formulation, analysis and synthesis of feedback models and real implementation. Emphasis on large social systems with intangible variables. Student project.

I.Sy.E. 6807. Feedback Dynamics Principles
3-0-3. Prerequisite: I.Sy.E. 6806.

Detailed model building. Simulation by hand and DYNAMO. Study of oscillation, growth, frequency sensitivity, phasing, noise in feedback models. Model trouble-shooting and improvement. Student project.

I.Sy.E. 6808. Feedback Dynamics Applications

3-0-3. I.Sy.E. 6806, 6807 suggested, but not required.

Design/modification of human organizations. Extensive student project illustrates principles presented in I.Sy.E. 6806-7 and provides exercise in creative real-system synthesis and recommendation implementation.

I.Sy.E. 6831. Advanced Simulation

3-0-3. Prerequisite: I.Sy.E. 4044, I.Sy.E. 6400.

Extension of discrete-event, digital simulation methods presented in I.Sy.E. 4044. Emphasis on model building and the design and analysis of simulation experiments for complex systems.

I.Sy.E. 6841. Decision Support Systems

2-3-3. Prerequisites: I.Sy.E. 6734 or equivalent, I.Sy.E. 6739 or equivalent.

Interactive computer support of design, analysis and decision making. Hands-on project in decision-aiding system development. APL programming language syntax and practice.

I.Sy.E. 7000. Master's Thesis

Required of degree candidates.

I.Sy.E. 7441. Linear Statistical Models I

3-0-3. Prerequisite: Math. 4241 and I.Sy.E. 6400.

Introduction to full rank linear statistical models, including least squares and maximum likelihood estimation, interval estimation and hypothesis testing. Regression models are discussed.

Text: at the level of Graybill, *Linear Statistical Models*.

I.Sy.E. 7442. Linear Statistical Models II

3-0-3. Prerequisite: I.Sy.E. 7441.

A continuation of I.Sy.E. 7441 emphasizing linear statistical models of less than full rank. Balanced designs, including fixed, mixed and random models are stressed.

Text: at the level of Graybill, *Linear Statistical Models*.

I.Sy.E. 7656. Advanced Queueing Theory

3-0-3. Prerequisite: I.Sy.E. 6656.

For those interested in advanced work and research. Topics include imbedded Markov chain queueing models, waiting times under various queue disciplines and current research problems.

I.Sy.E. 7671. Foundations of Optimization

3-0-3. Prerequisite: Math. 4311.

Conditions for optimality and nonlinear duality generalized to nonconvex functions, and its use in nonlinear programming.

Text: at the level of Mangasarian, *Nonlinear Programming*.

I.Sy.E. 7672. Optimization: Adjacent Extreme Point Methods

3-0-3. Prerequisite: I.Sy.E. 6669.

A study of current literature in adjacent extreme point methods including quasi concavity, recent duality results, complementary pivot theory, quadratic and stochastic programming.

I.Sy.E. 7673. Nonlinear Programming

3-0-3. Prerequisite: I.Sy.E. 6670.

Nonlinear programming algorithms with emphasis on strategy and convergence at the level of Zangwill, *Nonlinear Programming*. Derivative and derivative-free methods, Lagrange multipliers, penalty functions, conjugate directions, feasible directions and cutting planes.

I.Sy.E. 7674. Dynamic Programming I

3-0-3. Prerequisite: I.Sy.E. 6669 or equivalent.

Advanced treatment of the elements of modern dynamic programming via the state space formalism. Problem formulation, computational aspects and dimensionality reduction. Application to various fields.

I.Sy.E. 7675. Network Flows

3-0-3. Prerequisite: I.Sy.E. 6669.

Current literature in networks including characterization theorems and algorithms for flow problems, flow with gains, multicommodity flows, disconnecting sets and matching theory.

I.Sy.E. 7676. Combinatorial Optimization

3-0-3. Prerequisites: I.Sy.E. 6669 or consent of instructor.

Principal topics include independent sets and cliques in graphs, graph coloring, trees and circuits, planarity and matching. Some complexity issues are covered as well as worst case performance for efficient heuristics.

I.Sy.E. 7677. Integer Programming

3-0-3. Prerequisite: I.Sy.E. 6669.

The methods and applications of integer programming including cutting plane methods, implicit enumeration, heuristic techniques, group theoretic and other developments.

I.Sy.E. 7678. Decomposition Methods for Large Systems

3-0-3. Prerequisite: I.Sy.E. 6669.

Solution strategies, illustrated with examples, for handling complex systems with large number

of variables and/or restrictions, linear and nonlinear.

I.Sy.E. 7680. Advanced Location Theory

3-0-3. Prerequisite: I.Sy.E. 6670, 6680, or consent of school.

Theoretical aspects of location problems are emphasized, drawing upon results from linear and nonlinear programming, graph theory and network analysis. Recent research literature is covered.

I.Sy.E. 7765. Hospital Management Systems

1-6-3. Prerequisite: I.Sy.E. 6765 or consent of school.

Research projects addressed to real-life problems confronting operational health care institutions and employing modern principles and approaches of health systems analysis. Project report. Cross-listed as H.S. 7765.

I.Sy.E. 8001-2-3. Seminar

1-0-0 each.

I.Sy.E. 8100-1-2. Special Topics

3-0-3 each. Prerequisite: consent of school.

Special topic offerings not included in regular courses.

I.Sy.E. 8120-1-2. Topics in Safety Engineering

3-0-3 each. Prerequisite: consent of school.

This course will be devoted to special topic offerings in the field of safety engineering.

I.Sy.E. 8561-2-3. Seminar in Operations Research

Credit to be arranged. Prerequisite: consent of school.

Topics within the area of operations research of a special interest to the faculty and graduate students and which are not included in regularly offered courses.

I.Sy.E. 8581-2-3. Seminar in Systems Engineering

Credit to be arranged. Prerequisite: I.Sy.E. 6801.

Specific systems will be selected for detailed and in depth data collection, simulation and analysis utilizing the theory provided in the systems research and application courses.

I.Sy.E. 8601-2. Projects in Operations Research

Credit to be arranged. Prerequisite: consent of school.

This course provides, through project work, experience in the application of operations research methods to real-world systems.

I.Sy.E. 8704-5-6. Special Problems in Industrial Engineering

Credit to be arranged. Prerequisite: consent of school.

I.Sy.E. 9000. Doctoral Thesis

INFORMATION AND COMPUTER SCIENCE

Note: the four-digit course numbering system of the School of Information and Computer Science has several mnemonic features. The first digit indicates the course level (1xxx-4xxx undergraduate, 6xxx-9xxx graduate). The second digit designates the subject orientation of the course: theory and foundations (x1xx), professional milieu (x2xx), computing applications (x3xx), computer software (x4xx), numeric computing and mathematics (x5xx), computer hardware and systems (x6xx) and service courses (x7xx). The last three digits in the range x200 through x699 are identical with the subject codes of *Computing Reviews*, thus facilitating the student's access to the current literature related to these courses.

I.C.S. 1000. Information and Society

1-0-1.

Orientation to the I.C.S. discipline and school. Information technology in societal development. Career patterns in the information processing and computing professions.

I.C.S. 1001. Computing Facilities

0-3-1.

Introduction to the equipment and facilities of the school and of the Office of Computing Services. Emphasis on the effective use of the time-sharing systems.

I.C.S. 1116. Introduction to Linguistics

3-0-3.

Study of selected topics from grammar and semantics that are of importance to the processing of natural language.

I.C.S. 1400. Introduction to Algorithms and Computing

2-3-3.

First course on problem solving using computers. The concept and notation of algorithms. Problem analysis, development of algorithms and their implementation in a procedure oriented language.

I.C.S. 1700. Digital Computer Organization and Programming

2-3-3.

Algorithmic processes of problem solving, properties of algorithms, development of algorithms for the solution of numerical and non-numerical problems. The FORTRAN programming language. No credit for I.C.S. majors.

I.C.S. 2150. Introduction to Discrete Structures

3-0-3. Prerequisite: Math. 1308.

An introduction to concepts fundamental to the analysis of algorithms and their realizations. Topics included are induction, recursion, graphs, machines, Boolean algebras and combinatorics.

I.C.S. 2250. Technical Information Resources
1-0-1.

Introduction to the literature and information services of science, engineering and management. Effective uses of the Georgia Tech library.

I.C.S. 2400. Computer Programming

2-3-3. Prerequisite: I.C.S. 1400.

A continuation of the development of the discipline in program design and programming style using the advanced features of the PASCAL language.

I.C.S. 2600. Computer Organization and Programming

2-3-3. Prerequisite: I.C.S. 1400 or 1700.

Introduction to computer organization, machine-language programming and assembly systems. Internal data structures, selected programming techniques.

I.C.S. 2700. Computer and Programming Systems

2-3-3. Prerequisite: I.C.S. 1400 or 1700.

Introduction to digital computer systems, computer organization, assembly language programming and the structuring and processing of information. No credit for I.C.S. majors.

I.C.S. 3110. Semiotics
3-0-3.

Basic concepts of signs relevant to natural and artificial sign processing systems. The representation relation, classification of signs. Analysis of sign systems.

I.C.S. 3113. Information Structures and Processes

3-0-3. Prerequisite: I.C.S. 2600 (or 2700), 2400.

Logical data structures and their machine representation. Processes on data structures, including scanning, searching and sorting, with emphasis on list processing techniques.

I.C.S. 3140. Introduction to Discrete Systems

3-0-3. Prerequisite: I.C.S. 2150.

Basic classical and modern concepts and tools required for modelling, analysis and synthesis of discrete deterministic systems; elements of automata theory.

I.C.S. 3150. Introduction to Mathematical Logic

3-0-3. Prerequisite: I.C.S. 2150.

Introduction to formal systems for the logical appraisal of inferences, including quantification and identity theory, referential interpretation, first order languages, soundness and completeness.

I.C.S. 3155. Introduction to Theory of Computing I

3-0-3. Prerequisite: I.C.S. 2150.

Study of fundamental concepts in the formal theory of automata emphasizing finite state machines. Turing machines and computational power of machines.

I.C.S. 3342. Introduction to Computational Linguistics

3-0-3. Prerequisite: I.C.S. 1116, 3113.

Approaches to natural language processing by computer. Concordance construction, syntactic analysis, question-answering systems, mechanical translation and computer programs for linguistic research.

I.C.S. 3400. Automatic Data Processing

2-3-3. Prerequisite: I.C.S. 1700 or equivalent.

Development of algorithms for the solution of business oriented problems. File structure organization and processing on different types of storage devices. The COBOL programming language.

I.C.S. 3422. Survey of Programming Languages

3-0-3. Prerequisite: I.C.S. 3113.

Detailed study of programming techniques using a variety of programming languages such as SNOBOL 4, LISP, APL, COBOL, ALGOL, PL/1 and PASCAL.

I.C.S. 3510. Computer-Oriented Numerical Methods

3-0-3. Prerequisites: I.C.S. 1700 or 2400, Math. 1309.

Introduction to computer oriented numerical methods for error analysis, function evaluation, solution of systems of equations, curve-fitting, interpolation, numerical integration and differentiation.

I.C.S. 3600. Computer Systems I

3-0-3. Prerequisite or corequisite: I.C.S. 3113.

Basic hardware components of computer systems, their operation and organization. Topics include system structure, data representation, processors, control, storage, input/output and interrupts.

I.C.S. 3601. Computer Systems II

3-0-3. Prerequisite: I.C.S. 3600.

Basic system software and advanced computer organizations including operating systems, translators, run-time environment, microprogram

ming, minicomputers, and performance measurement and evaluation.

I.C.S. 3610. Computer Logic Design

3-0-3. Prerequisite: I.C.S. 3600.

Theory and design of digital logic systems, including minimization techniques. Applications to digital computer components. Demonstrations of actual logic systems.

I.C.S. 3705. Computer and Programming Systems

5-0-5. Prerequisite or corequisite: I.C.S. 3113.

Hardware and software components of digital computing systems emphasizing system software (operating systems and translators) and details of hardware organization. NOTE: This course is a combination of I.C.S. 3600 and 3601 offered without credit as a remedial course for ICS graduate students only.

I.C.S. 4110. Topics in Linguistics

3-0-3.

Study of selected topics in the grammar and semantics of natural language. The course is intended for graduate students with no prior background in linguistics.

I.C.S. 4117. Introduction to Mathematical Linguistics

3-0-3. Prerequisite: I.C.S. 1116, 2150, Math. 3215.

Application of statistical and algebraic approaches to the study of linguistic structures from the viewpoint of their utility to a wide range of problems.

I.C.S. 4120. Introduction to Information Processes I

3-0-3. Prerequisite: I.C.S. 1116, 2150, Math. 3215.

Explication of the information concept and its properties. Statistical theory of syntactic communication: information sources, information transmission, channel capacity and efficiency, coding, noisy communication channels.

I.C.S. 4121. Introduction to Information Processes II

3-0-3. Prerequisite: I.C.S. 2150.

Computer methods of clustering, identification, systematization and pattern recognition; empirical data processing, choice of measurement, feature selection, data reduction, optimality criteria; analysis of algorithms.

I.C.S. 4136. Problem Solving

3-0-3.

General approaches to problem solving, with emphasis on methods and techniques of formalizing intuitive heuristics. Structure of problems

and goals, generation of alternatives. Incomplete information.

I.C.S. 4153. Computing Languages

3-0-3. Prerequisite: I.C.S. 3150, 3422.

Introduction to formal study of syntax, semantics and logic of programming languages.

I.C.S. 4155. Introduction to Theory of Computing II

3-0-3. Prerequisite: I.C.S. 3155.

Introduction to the mathematical analysis of computer algorithms, correctness, complexity, asymptotic lower bounds, efficient data structures and combinatorial algorithms. NP-complete problems.

I.C.S. 4240. Project Communication and Management

3-0-3.

Application of communication techniques to the management of information systems projects. Practice in proposal preparation, system documentation, project reporting.

I.C.S. 4250. Literature of Science and Engineering

2-3-3. Prerequisite: I.C.S. 2250.

Study of the reference and bibliographic sources of scientific, engineering and management literature, emphasizing strategies of manual and computer searching. Bibliographic project in student's discipline.

I.C.S. 4300. Information Systems

3-0-3. Prerequisite: I.C.S. 1700 or 2400.

Empirical methodology of analysis and design of computer-based information systems, and its relationship with the definition of objectives, planning, analysis design, implementation and evaluation of such systems. Case studies.

I.C.S. 4305 Science Information Systems

3-0-3.

Information and communication in science. Design of science data banks, document repositories, information transfer services. Science information control at national and international levels.

I.C.S. 4334. Health Information Processing

3-0-3.

Information processing applications in health care and biomedical research. Patient records, automation of clinical laboratory, hospital information systems, diagnostic decision-making, biomedical documentation.

I.C.S. 4351. MIS Methodology

3-0-3. Prerequisite: I.C.S. 4300.

Methodology for the design and implementation of management information systems in in-

dustrial, business and governmental organizations. Feasibility studies; system development, implementation and evaluation. Project management.

I.C.S. 4360. Artificial Intelligence and Heuristics

3-0-3. Prerequisite: I.C.S. 2150, 3601.

Heuristic vs. algorithmic methods for automatic problem solving. Study of machines and programs that deduce answers to questions from given facts, play games, prove theorems.

I.C.S. 4370. Information Storage and Retrieval
3-0-3. Prerequisite: I.C.S. 3113, Math. 3215.

Computer-aided organization and retrieval of bibliographic and natural-language information. Topics include statistical, syntactic and logical analysis of information content, evaluation of retrieval effectiveness.

I.C.S. 4380. Data Communications

3-0-3. Prerequisite: I.C.S. 3601.

An introduction to data communications for computers and computer terminals, including communications media, codes, data transmission, multiplexing, communications software, protocols, switching and simple networks.

I.C.S. 4390. Computer Graphics

3-0-3. Prerequisite: I.C.S. 3113.

Introduction to computer graphics: underlying principles, devices, systems and applications. Hands-on experience with available hardware and software packages. Programming projects in computer graphics.

I.C.S. 4410. Introduction to Compilers

3-0-3. Prerequisite: I.C.S. 3422, 3600.

Study of the basic techniques of compiler design and implementation with consideration of the implementation characteristics of widely used programming languages.

I.C.S. 4430. Introduction to Operating Systems

3-0-3. Prerequisite: I.C.S. 3601.

A qualitative introduction to operating systems including multiprogramming concepts, resource allocation and management, other functions performed and operating system implementation.

I.C.S. 4450. Introduction to Data Base Design

3-0-3. Prerequisite: I.C.S. 3601.

Introduction to logical and physical structures of computer data base systems. Topics include file organization, directory decoding, searching, maintenance. Data Base Task Group Report.

I.C.S. 4560. Elements of Information Theory

3-0-3. Prerequisite: Math. 3215.

Mathematical theory of communication with emphasis on efficient transmission of information through noiseless and noisy channels; coding in information sources; properties of codes.

I.C.S. 4600. Computer Systems Laboratory

2-12-6. Prerequisite: I.C.S. 3601, 3610.

Intensive, hands-on computer laboratory for I.C.S. majors. Machine-level operations and programming. Modular synthesis of hardware and software functions. I.C. applications. Device interfacing.

I.C.S. 4620. Microprogramming

2-2-3. Prerequisite: I.C.S. 3600, 3610.

Introduction to the fundamental concepts and applications of microprogramming and microprogrammable systems including a study of emulation, microprogramming languages and microprogrammable computers.

I.C.S. 4651. Design Project I

0-3-1. Prerequisite: consent of school.

First quarter of an undergraduate thesis sequence consisting of an analytic or empirical investigation in an approved area of information and computer science. Proposal preparation.

I.C.S. 4652. Design Project II

0-3-1. Prerequisite: I.C.S. 4651.

Second quarter of undergraduate thesis sequence. System analysis and design.

I.C.S. 4653. Design Project III

0-12-4. Prerequisite: I.C.S. 4652.

Third quarter of undergraduate thesis sequence. System implementation and final project report.

I.C.S. 4754. Models of Human Information Processing

3-0-3. Prerequisite: Psy. 3304, I.C.S. 1700 or equivalent.

General and unified approaches to psychological and computer modeling of human information processes. Emphasis on neural, sensory, memory, semantic and conceptual processing. Also listed as Psy. 4754.

I.C.S. 4756. Human Factors in Software Development

3-0-3. Prerequisite: I.C.S. 2400 or equivalent, Psy. 3304.

Examines human factors in the Software design and application process from initial requirement and specification statements to coding, testing, implementation and maintenance. Also listed as Psy. 4756.

I.C.S. 4801-2-3-4-5-6. Special Topics

Credit Hours Equal Last Digit of Course Number. Prerequisite: consent of school.

Courses of timely interest to the profession, conducted by resident or visiting faculty.

I.C.S. 4901-2-3. Special Problems

Credit to be arranged. Prerequisite: consent of school.

Individual investigation of significant areas of information and computer science. Guided study and research.

I.C.S. 6100. Foundations of Information Science

3-0-3.

Methods of information control, including: empirical laws of information science; information measurement; assessment of information needs; data collection; indexing, abstracting and classification; evaluation.

I.C.S. 6114. Information Measures

3-0-3. Prerequisite: I.C.S. 2150, Math. 3215.

Theory of quantitative methods of information measurement. Measure functions, syntactic, semantic and pragmatic levels of information measurement. Applications in communication systems, decision-making, economic realms.

I.C.S. 6116. Advanced Topics in Linguistics

3-0-3.

Study of natural language as a semiotic system with emphasis on a model of grammar incorporating the syntactic, semantic and pragmatic dimensions of semiosis.

I.C.S. 6117. Mathematical Linguistics

3-0-3. Prerequisite: I.C.S. 4117.

Study of the mathematical structure of natural language using statistical and algebraic techniques.

I.C.S. 6130. Philosophy of Mind

3-0-3. Prerequisite: graduate standing.

Higher mental processes including learning, concept formation, problem solving and perception, considered in relation to artificial intelligence. Linguistic and physiological models of human information processes.

I.C.S. 6135. Theory of Communication

3-0-3. Prerequisite: I.C.S. 6130.

Man-machine communication is analyzed by reference to studies of behavioral decision, conversational systems and interactive measurement methods.

I.C.S. 6140. Systems Theory I

3-0-3. Prerequisite: I.C.S. 3140 or equivalent.

Discrete dynamic processes, state variable characterization, classification. Autonomous processes, open and closed subprocesses and interaction. Algorithmic processes. Switching

circuits, sequential machines, memory and delay. Linearity.

I.C.S. 6141. Systems Theory II

3-0-3. Prerequisite: I.C.S. 6140.

Discrete dynamic processes, recurrence equations and difference equations. Stability and convergence. Linearity, realizations, controllability and observability, response separation and transfer functions. Sensitivity, control and optimization.

I.C.S. 6144-5. Information Systems Design I, II

3-0-3 each. Prerequisite: I.C.S. 4300.

Analysis and synthesis of information systems, emphasizing mathematical modeling. Study of selected systems in areas such as data processing, management, command and control systems.

I.C.S. 6146. Cybernetics

3-0-3.

Roles of various functions in living systems and their actual or potential realization in computers.

I.C.S. 6152. Theory of Automata

3-0-3. Prerequisite: I.C.S. 4155.

Study of the significant results concerning finite automata, pushdown automata, linear bounded automata, Turing machines, recognizers of the four Chomsky phrase-structure languages.

I.C.S. 6153. Theory of Compiling and Translation

3-0-3. Prerequisite: I.C.S. 4410, I.C.S. 4153 or 6152.

A survey of theoretical topics related to compiler design and implementation: deterministic parsing, table processing, code generation, syntax-directed compiling, global optimization.

I.C.S. 6155. Analysis of Algorithms

3-0-3. Prerequisite: I.C.S. 2150, I.C.S. 3113.

Basic techniques for analyzing and designing efficient algorithms: upper and lower time-space bounds for data structure, sorting and combinatorial problems, algebraic algorithms.

I.C.S. 6156. Complexity of Computation

3-0-3. Prerequisite: I.C.S. 3150, 6155.

Advanced techniques for analyzing the time-space complexity of natural computational problems: proving the tractability or intractability of problems from algebra, combinatorics, computer science, geometry and number theory.

I.C.S. 6157. Advanced Theory of Computability

3-0-3. Prerequisite: I.C.S. 4155.

Advanced treatment of the theory of computa-

bility. Topics include recursive functions, recursively enumerable sets and relations, degrees of unsolvability, the recursion theorem and computational complexity.

I.C.S. 6240. Organization and Management of Information Industry
3-0-3.

Organization, operation and management of the information industry. Information economics. Software companies. Information brokers. Vendor relationships. Professional association. Issues of ethics, privacy, security and auditing.

I.C.S. 6334. Medical Information Systems
3-0-3. Prerequisite: I.C.S. 4334 or 4450.

Medical information systems for patient care, research and administration. Topics include the medical environment, current systems and trends, database systems and automated medical records.

I.C.S. 6347. Computer-Aided Modeling
2-3-3. Prerequisite: Math. 3215, I.C.S. 3600.

Modeling of complex systems especially for digital simulation. Statistical and other methodological considerations. Simulation versus mathematical, numerical and other analysis. Projects in modeling and simulations.

I.C.S. 6360. Artificial Intelligence
3-0-3. Prerequisite: I.C.S. 4360.

Advanced study of topics from heuristic search, automatic theorem proving, semantic information processing, representation theory and other current areas.

I.C.S. 6363. Pattern Recognition
3-0-3. Prerequisite: Math. 3215 or equivalent.

Selected topics from statistical pattern recognition; feature selection; decision functions; pattern classification; trainable pattern classifiers.

I.C.S. 6370. Information Control Methods
3-0-3.

Study of methods of information control, including assessment of information needs, data collection and reduction, manual and automatic indexing, abstracting and classification, evaluation and performance.

I.C.S. 6380. Computer Networks
3-0-3. Prerequisite: I.C.S. 4380, 4430.

In depth examination of the design and operation of computer networks covering computer hardware and software functions and design requirements and communication subsystems.

I.C.S. 6410. Computer Language Design
3-0-3. Prerequisite: I.C.S. 3422 or 4410.

Description, structure, analysis and design of

high level programming languages. Theoretical treatment of language specification, design aspects of names and types, data and control structures.

I.C.S. 6412. Syntax Directed Compilation
3-0-3. Prerequisite: I.C.S. 4410.

Detailed study of compiler implementation techniques, including table-driven syntax analysis, translation to intermediate language, optimization and object code generation.

I.C.S. 6430. Computer Operating Systems
3-0-3. Prerequisite: I.C.S. 4430.

A quantitative coverage of operating system functions emphasizing implementation techniques including sequential and concurrent processes, processor and storage management, scheduling and protection.

I.C.S. 6431. Design of Computer Operating Systems
1-6-3. Prerequisite: I.C.S. 6430.

A major systems programming project involving the modification or extension of an existing operating system and an evaluation of the results.

I.C.S. 6435. Computer Systems Evaluation
2-3-3. Prerequisite: Math. 3215, I.C.S. 6430.

Methods of evaluating performance of large-scale computer systems, with emphasis on performance analysis through simulation, queueing models and measurement.

I.C.S. 6450. Data Base Design
2-3-3. Prerequisite: I.C.S. 4450.

Study of the state-of-the-art of data base design. Approaches to data base formalisms and standardization. Term project.

I.C.S. 6530. Graph Theory
3-0-3. Prerequisite: I.C.S. 2150.

Algorithmic combinatorics, including topics in permutations, combinations, enumeration, graphs and trees, with applications in information and computer science.

I.C.S. 6555. Queueing Theory and Applications I
3-0-3. Prerequisite: Math. 3215, I.C.S. 3601.

Queueing theory and its application in computer performance evaluation, operating systems design, telecommunications and operations research.

I.C.S. 6556. Queueing Theory and Applications II
3-0-3. Prerequisite: I.C.S. 4430, 6555.

Continuation of I.C.S. 6555, emphasizing current research topics. Problems suitable for dissertation research are discussed.

I.C.S. 6600. Advanced Small Scale Computer Systems

1-6-3. Prerequisite: I.C.S. 3601, 3610.

The design and application of software and hardware for actual computer systems is introduced through hands-on laboratory experience with hardware modules, micro-computers and interface sub-systems.

I.C.S. 6620. Advanced Computer Organization
3-0-3. Prerequisite: I.C.S. 3601, 3610.

Studies of computer system organizations: advanced input/output systems, multiprocessors, pipeline processors, other parallel systems.

I.C.S. 6750. Human-Computer Interface
3-0-3. Prerequisite: consent of school.

Human-computer interface is considered in terms of user-system compatibility. Concepts in human factors and interface design are covered in relation to capabilities and limitations of both humans and computers. Also listed as Psy. 6750.

I.C.S. 7000. Master's Thesis

Credit to be arranged. Prerequisite: consent of school.

I.C.S. 7115. Philosophy of Language
3-0-3. Prerequisite: I.C.S. 6116.

Study of selected topics in linguistics arising from philosophic discussion of language. Emphasis on contributions of Russell, Carnap, Quine and Martin to modern linguistic thought.

I.C.S. 7999. Preparation for Doctoral Qualifying Exams.

Credit to be arranged. Prerequisite: consent of school.

I.C.S. 8001-2-3. Seminar
1-0-0 each. Prerequisite: consent of school.

I.C.S. 8111-2-3-4-5-6. Special Topics
Credit hours equal last digit of course number. Prerequisite: consent of school.

Special topics of current interest. Treatment of new developments in various areas of information and computer science.

I.C.S. 8501-2-3. Special Problems
Credit to be arranged. Prerequisite: consent of school.

Small-group of individual investigation of advanced topics in information and computer science. Guided study and research. Maximum of 5 credit hours allowed toward the I.C.S. M.S. degree.

I.C.S. 8999. Doctoral Thesis Preparation
Credit to be arranged. Prerequisite: consent of school.

I.C.S. 9000. Doctoral Thesis

Credit to be arranged. Prerequisite: consent of school.

LINGUISTICS

See Modern Languages.

MANAGEMENT Economics

Econ. 2000. Principles of Economics I

3-0-3. Prerequisite: sophomore standing.

The behavior of economic units in pricing and output decisions.

Econ. 2001. Principles of Economics II

3-0-3. Prerequisite: sophomore standing

Surveys national income, employment, money and banking and international trade. Relates consumer, business, government and international sectors to the aggregate economy.

Econ. 3000. Economic Theory of the Firm

3-0-3. Prerequisite: Econ. 2000-1.

Intermediate price theory with applications to management problems.

Econ. 3001. National Income Analysis

3-0-3. Prerequisite: Econ. 2000-1.

An intermediate macroeconomic theory course to enable the student to analyze the national economic environment relative to the firm and stabilization of the national economy.

Econ. 3002. Money and Banking.

3-0-3. Prerequisite: Econ. 2000-1.

An analysis of how money fits into the economic system and the problems of administering monetary policy both domestically and internationally.

Econ. 3095. Seminar in Economic Policy

3-0-3. Prerequisite: Econ. 3000-1.

Topics for discussion will be chosen to encourage the student to focus understanding of economic theory on a substantive problem. Designed for economics majors.

Econ. 3100. Econometrics I

3-0-3. Prerequisite: M.Sci. 3111.

An introduction to the statistical methods for estimating the quantitative relationships among economic variables. Topics include model specification, parameter estimation, prediction and verification.

Econ. 3400. The Process of American Industrial Development

3-0-3. Prerequisite: Econ. 2000-1.

The forces, unique characteristics and problems associated with American industrialization.

Econ. 3401. European Economic History

3-0-3. Prerequisite: Econ. 2000-1.

An economic survey of the major institutions, inventions and innovations of the commercial revolution, the agricultural revolution and the industrial revolution in Europe.

Econ. 3410. Economic Development

3-0-3. Prerequisite: Econ. 2000-1.

General theories of economic development. Each student will be required to analyze the economy of a developing country.

Econ. 3500. Scope and Method of Political Economy

3-0-3. Prerequisite: Econ. 2000-1.

The logical structure of scientific theory as it applies to knowledge about political and economic situations and events.

Econ. 3501. Political Economy: Public Policy Analysis I

3-0-3. Prerequisite: Econ. 2000-1.

A theoretical perspective to explain and predict the effects of actual and proposed public policy and to generate some standards of evaluation.

Econ. 4000. Topics in Advanced Microeconomics

3-0-3. Prerequisite: Econ. 3000-1.

Selected topics in advanced microeconomics. Designed for economics majors.

Econ. 4050. Monetary Theory and Policy

3-0-3. Prerequisite: Econ. 3001.

Determinants of supply and demand for money and the effect of changes in these determinants on interest rates, prices and the level of national income.

Econ. 4100. Econometrics I

3-0-3. Prerequisite: Econ. 3100.

A detailed discussion of the problems encountered in empirical econometric studies. Emphasis is placed on data problems and errors in estimation and prediction.

Econ. 4110. Mathematical Economics

3-0-3. Prerequisite: Econ. 2000-1.

Emphasizes the application of mathematical tools to economic analysis. Topics include static analysis, comparative-static analysis, optimization and dynamic analysis.

Econ. 4120. Economic Forecasting

3-0-3. Prerequisite: Econ. 2000-1.

Cyclical fluctuations in the total economy are examined empirically. Methods of making forecasts of national and industry performance are presented.

Econ. 4230. Economics of the Labor Market

3-0-3.

The application of microeconomic theory to wages, employment and productivity.

Econ. 4231. Labor History

3-0-3.

A survey of the times and conditions facing the working class in attempting to establish a body of industrial jurisprudence.

Econ. 4235. Protective Labor Legislation

3-0-3.

Federal and state regulation of worker security against occupational injury, unemployment, old-age, disability and discrimination, plus wage and hour legislation.

Econ. 4265. U.S. Labor Relations Law

3-0-3. Prerequisite: Mgt. 4200.

An examination of labor legislation, court decisions and NLRB rulings on labor-management relations.

Econ. 4300. International Economics

3-0-3. Prerequisite: two of Econ. 2000-1.

Foreign trade and commercial policy, international finance and current problems of international economic relations.

Econ. 4310. Public Finance

3-0-3. Prerequisite: Econ. 2000-1.

Analyzes government's role in resource allocation, income distribution, stabilization and growth through the economic effects of government spending and revenue raising activities.

Econ. 4320. Managerial Economics

3-0-3. Prerequisite: Econ. 3000.

Relationships between economic concepts and managerial decisions. Topics covered include nonprofit goals of the firm, unstructured managerial decisions.

Econ. 4330. Regional Economics

3-0-3. Prerequisite: Econ. 2000-1.

Theories of regional income determination and regional growth, spatial economic structure, central-place theory and regional effects of public policy.

Econ. 4331. Urban Economics

3-0-3. Prerequisite: Econ. 2000-1.

The economic dimensions of the processes and problems associated with urbanization.

Econ. 4332. Economics of Location

3-0-3. Prerequisite: Econ. 3000.

A survey of economic factors influencing industrial location. Consideration will be given locational patterns, the impact of transfer processing costs and land use competition.

Econ. 4340. Economics of Industrial Competition

3-0-3. Prerequisite: Econ. 2000-1.

The competitive structure of the American economy in terms of economic models, alternative public policy goals and the development of anti-trust laws.

Econ. 4341. Economics of Regulated Industries

3-0-3. Prerequisite: Econ. 2000-1.

The problems and policy options associated with government regulation of particular industries.

Econ. 4400. History of Economic Thought

3-0-3. Prerequisite: Econ. 2000-1.

A historical survey of schools of economic thought. The main body of the course is concerned with classical, neoclassical, Marxist, Keynesian and modern economic thought.

Econ. 4410. Industrial Development in Latin America

3-0-3. Prerequisite: Econ. 2000-1.

The principles of industrial development in emerging nations. The student prepares an analysis of the problems in a specific Latin American country.

Econ. 4420. Comparative Economic Systems

3-0-3. Prerequisite: Econ. 2000-1.

A critical study is made of the methods by which various economic systems meet common fundamental problems in production, exchange, distribution and capital formation.

Econ. 4500. Political Economy: Nonmarket Decision Making I

3-0-3. Prerequisite: Econ. 2000-1.

Collective choice through an economic-rational choice perspective, seeking to explain and predict the relationships among campaigns, voting and public policy toward private enterprise.

Econ. 4501. Political Economy: Nonmarket Decision Processes II

3-0-3.

The economics and politics of change, technological progress, price effects on innovation and trade-offs between economic efficiency and political expediency in national policies for energy, research, etc.

Econ. 4801-2-3. Special Topics in Economics

3-0-3 each.

A course designed to permit students to pursue a specialized interest in an area of economics not extensively treated in the offerings of the college.

Econ. 4811-2-3-4-5. Special Topics in Economics

1-0-1 through 5-0-5 respectively.

Courses designed to permit students and a professor to pursue a specialized interest in an area of economics not extensively treated in the offerings of the college.

Econ. 4901-2-3. Individual Research in Economics

Credit to be arranged.

Designed to permit independent study with a faculty member. To register, the student must obtain written approval of the associate dean and of the sponsoring professor.

Econ. 4990. Georgia Internship Program

Credit to be arranged. Prerequisite: consent of college.

Broadens the scope of the college curriculum by offering students a community-based learning experience which stresses the completion of a specific task.

Econ. 6000. Microeconomic Analysis and Policy

3-0-3. Prerequisite: consent of college.

Theoretical analysis of the determination of prices and output. The objective is to develop the basic economic concepts.

Econ. 6001. Macroeconomic Analysis and Policy

3-0-3. Prerequisite: consent of college.

National income accounting methods and the theory of national income determination.

Econ. 6005. Cost-Benefit Analysis

3-0-3. Prerequisite: Econ. 6000.

Methods for public project evaluation, including decision criteria, identifying and quantifying costs and benefits, sensitivity analysis and procedures for performing a cost-benefit analysis.

Econ. 6050. Monetary Theory

3-0-3. Prerequisite: Econ. 6001.

Theories of the role of money and the monetary system in economic stabilization and growth, analyses of monetary and fiscal policies.

Econ. 6120. Economic Forecasting

3-0-3. Prerequisite: Econ. 6001.

Macroeconomic theory and the analysis of overall economic conditions with their application to management problems of the industrial firm.

Econ. 6230. Labor and the Economy

3-0-3. Prerequisite: previous course in labor relations.

Case course involving contract negotiations, grievance handling and arbitration.

Econ. 6266. Wage and Employment Theory

3-0-3. Prerequisite: Econ. 6000, 6001.

An analysis of the economic theories and institutional developments explaining the terms, conditions and levels of employment.

Econ. 6300. International Trade and Finance

3-0-3. Prerequisite: Econ. 6001.

Foreign exchange market, foreign trade and commercial policy, international finance and current problems of international economics.

Econ. 6320. Managerial Economics

3-0-3. Prerequisite: Econ. 6000.

Relationships between economic concepts and managerial decisions. Topics covered include nonprofit goals of the firm, unstructured managerial problems and the determinants of good managerial decisions.

Econ. 6330. Regional Economics

3-0-3.

Survey of the economics of regions, emphasizing region delineation, systems of cities, measurement of regional activity, theories of income, employment and economic growth.

Econ. 6331. Economics of Industrialization

3-0-3.

An examination of long-run growth processes seeking causes of underdevelopment, exploring theories of economic growth and applying these explanations to developed and underdeveloped economies.

Econ. 6335. The Economics of Environmental Quality

3-0-3. Prerequisite: consent of college.

Topics included are the causes of market failure to provide a high quality environment, amenity resources and extra-market values.

Econ. 6340. Industry and Government

3-0-3. Prerequisite: Econ. 6000.

Organization and the structure of American industry, beginning with price theory under various forms of market structure.

Econ. 6400. Public Issues in Economic Policy

3-0-3.

Major public issues from the viewpoint of American economic history.

Econ. 6410. Development of Economic Thought

3-0-3. Prerequisite: Econ. 6000-1, consent of college.

Development of the various schools of economic thought and their contributions to the present body of economic theories. Credit not given for both Econ. 4400 and 6410.

Econ. 6430. Research Methods in Development

3-0-3.

General review of research techniques and to acquaint the student with the literature and reference sources in industrial development.

Econ. 6435. Development Seminar I

1-0-1. Prerequisite: Econ. 6410.

Planning and researching a project in industrial development.

Econ. 6436. Development Seminar II

3-0-3. Prerequisite: Econ. 6435.

Writing and presenting a research paper on industrial development. The paper may be either applied or theoretical in nature and should be of publishable quality.

Econ. 6500. Nonmarket Processes and Economic Decisions

3-0-3. Prerequisite: Consent of college.

Development of political economy and relation of political-economic processes to managerial decision-making.

Econ. 6501. Private and Public Spheres of Influence

3-0-3.

Processes of private and public decisions in a modern economy.

Econ. 6750. The Changing Economy

3-0-3.

This course examines the long run forces within the economy that support economic growth and rising standards of living. Studies the changes in these sources of growth due to the recent performance of the economy.

Econ. 6760. Financial Management and Economics of Nuclear Power

3-0-3.

Interdisciplinary relationship of the nuclear fuel cycle and reactor system to the electrical power industry treated as a system, effect of management decisions on the overall economics. Also listed as N.E. 6760.

Econ. 7010. Advanced Microeconomic Analysis

3-0-3. Prerequisite: Consent of college.

Analysis of resource allocation and income distribution.

Econ. 7011. Advanced Macroeconomic Analysis

3-0-3. Prerequisite: Consent of college.

Interrelationships among the major aggregated sectors of a national economy taking special cognizance of institutions which exist in U.S.

Econ. 7020. Seminar in Microeconomics

3-0-3. Prerequisite: Econ. 7010 and consent of college.

Students have an opportunity to pursue in depth some topic or problem in the area of microeconomics.

Econ. 7021. Seminar in Macroeconomics

3-0-3. Prerequisite: Econ. 7011 and consent of college.

Students have an opportunity to pursue in depth some topic in the area of macroeconomics.

Econ. 7100. Econometrics

3-0-3. Prerequisite: consent of college.

An analysis of the problems of heteroscedasticity, multicollinearity, underidentification and autocorrelation as whole.

Econ. 7101. Seminar in Econometrics

3-0-3. Prerequisite: Econ. 7100 and consent of college.

Empirical economic research.

Econ. 8401-2-3-4-5-6. Special Topics

1-0-1 through 6-0-6. Prerequisite: consent of college.

Topics of current interest in the field of economics.

Econ. 8501-2-3-4. Special Problems

Credit to be arranged. Prerequisite: consent of college.

Provides project work experience in the field of economics.

Econ. 9000. Doctoral Thesis**Management****Mgt. 2000. Accounting I**

3-0-3. Prerequisite: sophomore standing.

Provides a general understanding of financial accounting systems and an interpretation of financial reports.

Mgt. 2001. Accounting II

3-0-3. Prerequisite: Mgt. 2000

Provides a general understanding of cost accounting systems with emphasis on the manufacturing situation.

Mgt. 2002. Accounting III

3-0-3. Prerequisite: Mgt. 2001

Provides a general understanding of management applications of accounting output in a decision context.

Mgt. 3010. Taxation

3-0-3. Prerequisite: Mgt. 2000.

Business income tax requirements and the management planning necessitated by various tax alternatives. Some attention to personal income taxes.

Mgt. 3020. Accounting Theory and the Analysis and Interpretation of Financial Statements

4-0-4. Prerequisite: Mgt. 2002.

Accounting techniques and principles for measuring assets, equities and earnings of manufacturing and financial corporations. Includes revenue recognition, inventory valuation, accounting theory, etc.

Mgt. 3021. Topics in Managerial Accounting and Control

3-0-3. Prerequisite: Mgt. 2002 and consent of the instructor.

Advanced topics in managerial reporting and analysis, such as divisional performance measurement, capital budgeting under uncertainty, budgeting, control and other issues in internal resource allocation.

Mgt. 3050. Computer-Based Management Systems

3-0-3. Prerequisite: M.Sci. 2000.

An introduction to concepts used in the design of management systems relying on computers and information technology.

Mgt. 3060. Finance I

3-0-3. Prerequisite: Econ. 2000. Mgt. 2001, and M.Sci. 3100 or an equivalent statistics course.

Introduces the institutions and instruments for acquisition of funds and stresses their utilization within an economic environment for making financial decisions.

Mgt. 3061. Finance II

3-0-3. Prerequisite: Mgt. 3060.

Application of capital budgeting techniques to the firm, including selection from alternative investment opportunities, determining cost of capital and treatment of uncertainty.

Mgt. 3070. Management Science Models in Finance

3-0-3. Prerequisite: Mgt. 3060.

A study of the analytical techniques in finance including capital budgeting, portfolio theory and capital market theory.

Mgt. 3080. Investments

3-0-3. Prerequisite: Mgt. 3060 or 3701.

An introduction from a theoretical point of view to the selection and acquisition of proper securities for managing portfolios with different goals.

Mgt. 3100. Organizational Development

3-0-3. Prerequisite: Mgt. 3150 or consent of college.

Analysis of the structural development of the organization. Particular emphasis is given to organization-environment interfaces, effectiveness and efficiency. Managing technology and change.

Mgt. 3150. Management Theory

3-0-3.

Provides students with a fundamental management theory matrix essential to the understanding of management, process and role.

Mgt. 3160. Management in a Changing Society

3-0-3.

Role of the manager in today's era of pervasive change, viewing the firm as a socio-economic agent of the society.

Mgt. 3161. Management as a Creative Force

3-0-3. Prerequisite: Mgt. 3160.

Describe the manager's role in accomplishing the entrepreneurial mission of the enterprise. Each student analyzes and reports on an existing organization.

Mgt. 3260. Business Law I

3-0-3.

Development and function of the law, court organization, procedure and substantive law in contracts, business organizations, and agencies.

Mgt. 3261. Business Law II

3-0-3.

Legal problems encountered in an urban environment within a socioeconomic and political atmosphere, specifically in the areas of consumer problems, bankruptcy and constitutional law.

Mgt. 3300. Marketing I

3-0-3. Prerequisite: Econ. 2000.

Marketing's role in productive process, basic buyer behavior, market segmentation concepts, the management of marketing activities, environmental influences on marketing management.

Mgt. 3301. Marketing Management

3-0-3. Prerequisite: Mgt. 3300.

Emphasis on marketing management problems through the process of analysis, planning and control, case analysis and readings.

Mgt. 3310. Marketing Research

3-0-3. Prerequisite: Mgt. 3300, M.Sci. 3100.

Research orientation, planning an investigation, questionnaires, sampling, interpretation of results, report presentation.

Mgt. 3320. Management Science Models in Marketing

3-0-3. Prerequisite: Mgt. 3300, M.Sci. 2000, M.Sci. 3100, M.Sci. 3400.

The use of management science models to solve marketing management problems, application rather than theory is stressed.

Mgt. 3330. Contemporary Issues in Marketing

3-0-3. Prerequisite: Mgt. 3300.

Course is designed to encourage students to examine the principles of marketing in light of contemporary thinking concerning social, economic and technological development.

Mgt. 3700. Analysis of Financial Data

4-0-4. Not open to College of Mgt. undergraduates.

A survey of general and cost systems. Emphasis on the use of accounting data. Credit not given for Mgt. 3700 and any other undergraduate accounting course.

Mgt. 4020. Auditing and Accounting Systems

3-0-3. Prerequisite: Mgt. 2001, 3060.

Emphasizes both the design of accounting systems and external and internal auditing and control procedures.

Mgt. 4022. Special Problems in Financial Reporting

4-0-4. Prerequisite: Mgt. 3020.

Consolidations, funds statements, earnings per share, results of operations, mergers and poolings, general price level adjustments, foreign exchange transactions and not-for-profit organizations.

Mgt. 4024. Seminar in Financial Reporting and Control

4-0-4. Prerequisite: Mgt. 2002 and consent of the instructor.

In-depth study of one or two major current issues in accounting, involving controversy and a significant possibility of substantial impact on theory and practice.

Mgt. 4040. Auditing Concepts

4-0-4. Prerequisite: Mgt. 4022 or consent of the instructor.

Problems in certifying financial statements, including audit objectives, statistical approaches to audit scope and auditing complex computerized data systems.

Mgt. 4100. Organizational Analysis

3-0-3. Prerequisite: Mgt. 3150 or consent of college.

Analysis of internal outcomes of the organizing process. The individual-organization interface is studied to understand perception, motivation, group formation and leadership within the firm.

Mgt. 4110. The Management of Organized Effort

3-0-3. Open only to seniors.

Management as a process of developing and controlling situations toward which people act and respond, both individually and as members of groups.

Mgt. 4115. Contemporary Management Thought

3-0-3. Prerequisite: Mgt. 3150 or consent of college.

This course emphasizes the impact of changing social values on management thought and practices. Guest speakers make important contributions to the course.

Mgt. 4120. Contemporary Research in Management

3-0-3. Prerequisite: either Mgt. 3100, 4100 or consent of college.

Investigations, analysis, critiques and reports of current research orientations in management. Students learn how management research is done.

Mgt. 4140. Personnel Management Problems

3-0-3. Prerequisite: Mgt. 3150 or consent of college.

Analysis of the personnel management process with emphasis placed upon the role and contribution to the firm of the staff function of personnel administration.

Mgt. 4151. Management of Industrial Research and Development Programs.

3-0-3. Normally taken by seniors.

Analysis of managerial considerations involved in conducting industrial basic and applied research programs and their integration with marketing, manufacturing and finance activities of the firm.

Mgt. 4160. Management Concepts and Issues in World Business

3-0-3. Normally taken by seniors.

Covers significant aspects of international business, changing patterns of world industry, emergence of common markets, role of U.S. industry overseas.

Mgt. 4165. Seminar

1-0-1. Junior standing.

Lectures and discussions with prominent business, government, labor and educational leaders. Offered winter quarter only.

Mgt. 4170. Career Analysis

3-0-3.

A course designed to enable students to analyze classified jobs in a company to determine career paths, training provided and counseling for workers.

Mgt. 4180. Industrial Management Honors Seminar

3-0-3. Last or next to last quarter seniors by faculty invitation.

Gives outstanding seniors an opportunity to research, analyze and discuss current management and economic problems.

Mgt. 4195. Integrated Management Problems

3-0-3. Prerequisite: senior standing and Mgt. 3150, 3300, a marketing elective, Mgt. 3061 or 3070 and 4350.

Comprehensive cases are used to integrate knowledge at the policy level of management and to relate managerial decisions to the economic and competitive forces affecting business.

Mgt. 4200. Industrial Relations

3-0-3.

Theories of the labor movement, union-management relationship, including the legal setting, contract negotiations, contract administration and the roles and nature of third parties.

Mgt. 4201. Contemporary Unionism and Collective Bargaining.

3-0-3. Prerequisite: Mgt. 4200.

A study of union structure, collective bargaining procedures and the analysis of union-management contracts.

Mgt. 4202. Cases in Labor-Management Relations

3-0-3. Prerequisite: Mgt. 4200.

A case study of problem areas in union-management relations. The cases used will be actual NLRB and labor arbitration decisions.

Mgt. 4250. Nonmarket Environment of the Firm

3-0-3. Open only to seniors.

An examination of the sociocultural factors which must be taken into account in the management decision process and of the forces which lead to their change through time.

Mgt. 4290. Public Administration

3-0-3.

An examination of the managerial function of federal, state and local governments with em-

phasis on the role of their interaction with the private sector.

Mgt. 4331. Consumer Behavior

3-0-3. Prerequisite: Mgt. 3300.

Stresses the impact of buyer decisions on the firm's marketing functions. Discusses economic, psychological, sociological, anthropological and organization impacts on buyer decisions.

Mgt. 4335. International Marketing

3-0-3. Prerequisite: Mgt. 3300.

Emphasis on international comparative analysis, the role of marketing in economic development and marketing strategies and policies of multinational firms.

Mgt. 4350. Production Management

3-0-3. Prerequisite: Mgt. 3150, M.Sci. 3400.

The organizational, economic and physical setting in which production occurs. Methods to analyze and improve production processes.

Mgt. 4801-2-3. Special Topics in Industrial Management

3-0-3 each.

Permits groups of students and a professor to pursue areas of management not extensively treated in other courses.

Mgt. 4811-2-3-4-5. Special Topics in Management

1-0-1 through 5-0-5 respectively.

Permits a group of students and a professor to pursue areas of management not extensively treated in other courses of the college.

Mgt. 4901-2-3. Individual Research in Industrial Management

Credit to be arranged.

Designed to permit independent study with a faculty member. To register, the student must obtain the written approval of the associate dean and of the sponsoring professor.

Mgt. 4990. Georgia Internship Program

Credit to be arranged. Prerequisite: consent of college.

Broadens the scope of the college curriculum by offering students a community-based learning experience which stresses the completion of a specific task.

Mgt. 6000. Management Accounting and Control

3-0-3. Prerequisite: consent of college.

Covers the use of accounting systems to provide information for performance evaluation.

Mgt. 6001. The Budget Process

3-0-3. Prerequisite: Mgt. 6000 and consent of college.

Develops the concepts of planning, budgeting and control as they relate to large resource allocation decisions.

Mgt. 6020. Accounting Theory and the Analysis and Interpretation of Financial Statements

4-0-4. Prerequisite: Mgt. 6000.

Accounting techniques and principles for measuring assets, equities and earnings of manufacturing and financial corporations. Includes revenue recognition, inventory valuation, accounting theory, etc.

Mgt. 6021. Topics in Managerial Accounting and Control

3-0-3. Prerequisite: Mgt. 6001 and consent of college.

Advanced topics in managerial reporting and analysis, such as divisional performance measurement, capital budgeting under uncertainty, budgeting, control and other issues in internal resource allocation.

Mgt. 6022. Special Problems in Financial Reporting

4-0-4. Prerequisite: Mgt. 6020.

Consolidations, funds statements, earnings per share, results of operations, mergers and poolings, general price level adjustments, foreign exchange transactions and not-for-profit organizations.

Mgt. 6023. Behavioral Aspects of Control

3-0-3. Prerequisites: Mgt. 6001, 6100.

The relationship between planning, budgeting and control processes in complex organizations and their interaction with organization structure, managerial behavior, information systems and financial performance.

Mgt. 6024. Seminar in Financial Reporting and Control

4-0-4. Prerequisite: Mgt. 6000 and consent of college.

In-depth study of one or two major current issues in accounting, involving controversy and a significant possibility of substantial impact on theory and practice.

Mgt. 6025. Socioeconomic Accounting

4-0-4. Prerequisite: Mgt. 6001

Use and limitations of accounting analysis in defining and measuring the economic costs, benefits and effectiveness of public projects and not-for-profit organizations.

Mgt. 6030. Financial Control I

4-0-4.

The general and cost accounting system of the firm will be studied as a managerial information system.

Mgt. 6031. Financial Control II

3-0-3. Prerequisite: Mgt. 6030.

Principles, problems and methods of accumulating, analyzing and interpreting accounting data.

Mgt. 6032. Financial Control III

3-0-3. Prerequisite: Mgt. 6031.

Applies decision principles developed in Mgt. 6031.

Mgt. 6040. Auditing Concepts

4-0-4. Prerequisite: Mgt. 6022 or consent of college.

Problems in certifying financial statements, including audit objectives, statistical approaches to audit scope, and auditing complex computerized data systems.

Mgt. 6041. Taxation and Decisions

4-0-4. Prerequisites: Econ. 6000, 6001 and Mgt. 6000 or consent of college.

A comprehensive examination of the major provisions of the Internal Revenue Code. Emphasis is placed upon the impact of taxes on business decisions.

Mgt. 6060. Financial Management I

3-0-3. Prerequisites: graduate standing and Mgt. 6001, M.Sci. 6020.

Modern finance emphasizing concepts useful to the nonfinancial manager. Financial statement analysis, financial projections and forecasting, time value, costs of capital, capital budgeting, risk and valuation.

Mgt. 6061. Financial Management II

3-0-3. Prerequisites: Mgt. 6060, M.Sci. 6021.

Financial structure, dividend policy, financial instruments, debt maturity structure, introduction to portfolio theory, asset pricing, market efficiency, capital markets, investment banking, banking, financial institutions and working capital.

Mgt. 6062. Theory of Financial Management

3-0-3. Prerequisite: Mgt. 6061.

Financial policy, theory and cases dealing with variety of topics in corporate finance.

Mgt. 6063. Corporate Cash Management and Banking Relations

3-0-3. Prerequisites: Mgt. 6061, M.Sci. 6022.

Daily cash management, short-term securities, cash planning, cash forecasting, credit lines, short-term financing, banking relations, collection systems, credit policy and other aspects of the corporate treasurer's job.

Mgt. 6064. Financial Planning Systems

3-0-3. Prerequisites: Mgt. 6063, M.Sci. 6055.

Computer-based financial statement generators and budgeting systems, short- and long-term financial models, computer-based capital budgeting systems and a variety of other financial planning models.

Mgt. 6065. Seminar in Financial Management

3-0-3. Prerequisite: Mgt. 6061.

Topics of current interest in the field of financial management.

Mgt. 6066. Capital Budgeting

3-0-3. Prerequisite: Mgt. 6060.

Concepts and techniques of evaluating investment proposals from the perspective of the firm. Topics include alternative investment criteria, inflation effects, capital rationing and investment timing.

Mgt. 6080. Investments

3-0-3. Prerequisites: Mgt. 6061, M.Sci. 6022.

Valuation of securities, portfolio theory, the efficiency of capital markets, asset pricing theory.

Mgt. 6100. Organization Processes

3-0-3. Prerequisite: consent of college.

Introduction to analysis of individual behavior and to individual and group performance in organizations.

Mgt. 6101. Organizational Problems, Theory and Application

3-0-3. Prerequisite: consent of college.

Introduction to, and analysis of various theories of organization in terms of goals, form and social setting. Organizational design-performance relationships are key issues considered.

Mgt. 6105. Individuals in Organizations

3-0-3. Prerequisite: graduate standing, consent of college.

Combines the theory of management with a workable knowledge of the behavioral sciences in achieving the objective of management.

Mgt. 6106. Group Processes in Organizations

3-0-3. Prerequisite: Mgt. 6105.

Administrative problems that arise in the relationships among people in organizations.

Mgt. 6107. Organization Theory

3-0-3.

Background for student to build sound organizational structure within the objectives of the enterprise.

Mgt. 6140. Management Systems Analysis

3-0-3.

An analysis of the environmental factors and forces that interact to form systems and their resultant impact upon the practice of management.

Mgt. 6155. Development of Management Thought
3-0-3.

A survey of the development of management thought based upon a critical examination of classic works in management literature.

Mgt. 6160. Management Theory
3-0-3. Prerequisite: consent of college.

Provides resources essential to the development of a matrix of management theory at the professional level.

Mgt. 6170. The Entrepreneur, Innovation and Change
3-0-3.

The role of the entrepreneur and innovation in economic development.

Mgt. 6180. Multinational Business
3-0-3. Prerequisite: consent of college.

Critical examination of business concepts, organizational structures and control processes of the multinational corporation in different political and economic environments.

Mgt. 6195. Managerial Policy
3-0-3. Prerequisite: Mgt. 6000, 6100, Econ. 6000 and two of Mgt. 6001, 6060, 6300, 3650.

Economic, competitive and governmental forces affecting the formulation of corporate strategy and managerial policies and decision-making.

Mgt. 6196. Managerial Policy II
3-0-3.

An examination of selected strategic issues, problems and competitive strategies in particular industries and types of organizations, combined with field projects and guest lecturers.

Mgt. 6200. Labor Problems
3-0-3.

An examination of the union-management relationship. Includes analysis of labor agreement, grievance procedures and arbitration and the legal environment of labor relations.

Mgt. 6260. The Legal Environment
3-0-3.

The role of law in society, legal philosophy and basic legal concepts.

Mgt. 6300. Marketing Management I
3-0-3.

Critical analysis of the marketing functions of an industrial enterprise, organizing and control of marketing programs emphasized.

Mgt. 6301. Marketing Management II
3-0-3. Prerequisite: Mgt. 6300.

Advanced course in marketing analysis and strategy formulation. Particular emphasis will be given to application of materials from Mgt. 6300.

Mgt. 6310. Marketing Research and Analysis
3-0-3. Prerequisite: Mgt. 6300.

Theory and techniques of marketing analysis and its use in the formulation of policy and strategy.

Mgt. 6320. Marketing Models
3-0-3. Prerequisite: Mgt. 6300 and a knowledge of probability and statistics.

Marketing models utilizing probability and statistics as well as behavioral techniques.

Mgt. 6330. Consumerism and Public Policy Issues in Marketing
3-0-3. Corequisite: Mgt. 6300.

Recent issues in consumerism, the performance of marketing activity within our society.

Mgt. 6350. Production and Operations Management I
3-0-3. Prerequisite: M.Sci. 6020 or equivalent. Corequisite: M.Sci. 6022 or equivalent.

Processes and management of production of goods and services. Methods to analyze, improve and plan production. Case studies.

Mgt. 6351. Production and Operations Management II
3-0-3. Prerequisite: Mgt. 6350.

Continuation of Mgt. 6350 with more emphasis on computer models.

Mgt. 6750. The Changing Economy
3-0-3.

This course examines the long run forces within the economy that support economic growth and rising standards of living. Studies the changes in these sources of growth due to the recent performance of the economy.

Mgt. 7000. Master's Thesis

Mgt. 7090. Management Research Methods
3-0-3. Prerequisite: consent of college.

Seminar in research techniques being employed in the current literature of management and economics.

Mgt. 7091. Seminar in Management and Economic Research
3-0-3. Prerequisite: consent of college.

Student pursues a primary area of interest to prepare a formal plan for future research.

Mgt. 7140. Management Systems Theory
3-0-3. Prerequisite: consent of college.

Fosters the investigation of managerial relationships existing among the diverse elements.

Mgt. 7750. Seminar on Psychology and Management

3-0-3. Prerequisite: Psy. 6601 or 6609, Mgt. 6150 or 6105 and consent of college.

Selected management problems involving psychological complexities, individual behavior in an organizational setting. Also listed as Psy. 7750.

Mgt. 8401-2-3-4-5-6. Special Topics

1-0-1 through 6-0-6 respectively. Prerequisite: consent of college.

Topics of current interest in the field of management.

Mgt. 8501-2-3-4. Special Problems

Credit to be arranged. Prerequisite: consent of college.

Provides project work experience in the field of management.

Mgt. 8801-2-3-4. Management Research

Credit to be arranged.

Credit given for the presentation of a satisfactory written report embodying the results of intensive research and study of a management problem. Conferences will be arranged.

Mgt. 9000. Doctoral Thesis

Management Science

M.Sci. 2000. Management Applications of Data Processing
2-3-3.

Provides a technical foundation for the development of computer-based management systems.

M.Sci. 3100. Survey of Statistics

3-0-3. Prerequisite: Math 1711.

A survey of discrete probability and statistics with emphasis on economic and business applications. Serves as core requirement for I.M. degree. Credit cannot be obtained for M.Sci. 3100 and either or both M.Sci. 3110 and M.Sci. 3111.

M.Sci. 3110. Statistics I

3-0-3. Prerequisite: Math. 1713, 1711.

Emphasis on continuous probability models and discrete models. Required of economics majors and recommended to those wanting a two course sequence in statistics. Credit cannot be obtained for M.Sci. 3110 and M.Sci. 3100.

M.Sci. 3111. Statistics II

3-0-3. Prerequisite: Math. 1713, 1711.

Classical inference and estimation drawing heavily on calculus for such topics as maximum likelihood estimation, evaluation of decision rules, etc. Credit cannot be obtained for M.Sci. 3111 and M.Sci. 3100.

M.Sci. 3200. Management Science I

3-0-3. Prerequisite: matrix algebra.

Applications of linear programming to the analysis of managerial problems. Topics include duality, transportation problems and postoptimal analysis.

M.Sci. 3201. Management Science II

3-0-3. Prerequisite: Math. 3215.

This second course in the methodology and application of management science is concerned with the use of stochastic models in the analysis of managerial and economic decision-making.

M.Sci. 3300. Decision Analysis in Management

3-0-3. Prerequisite: Math. 1711.

An introduction to decision models for management situations under risk and uncertainty including fundamental economic concepts of a theory of rational choice.

M.Sci. 3400. Analytical Methods in Management I

3-0-3. Prerequisite: Math. 1711.

Introduction to management science. Analytical models of management decision situations. Topics include classical optimization and linear programming.

M.Sci. 3401. Analytical Methods in Management II

3-0-3. Prerequisite: M.Sci. 3400 or 3200.

Additional applications of linear programming to analysis of management decision problems. Topics include alternatives to the simplex algorithm and special applications.

M.Sci. 3402. Analytical Methods in Management III

3-0-3. Prerequisite: M.Sci. 3400 or 3200.

Introduction to the theory and applications of dynamic, integer and nonlinear programming in the analysis of management decision problems.

M.Sci. 3403. Analytical Methods in Management IV

3-0-3. Prerequisite: M.Sci. 3100 or 3110.

Analytical and simulation approaches to the analysis of queueing and inventory systems.

M.Sci. 4100. Management Statistics

3-0-3. Prerequisite: consent of college.

Statistical fundamentals and techniques for graduate students with diverse backgrounds.

M.Sci. 4110. Introduction to Sampling

3-0-3. Prerequisite: statistical inference.

Theory and applications of sampling techniques with applications to substantive management and economic research problems.

M.Sci. 4801-2-3. Special Topics in Management Science

3-0-3 each. Normally taken by seniors.

Designed to permit students and a professor to pursue a specialized interest in an area of management science not extensively treated in the offerings of the college.

M.Sci. 4811-2-3-4-5. Special Topics in Management Science

1-0-1 through 5-0-5 respectively.

Designed to permit students and a professor to pursue a specialized interest in an area of management science not extensively treated in the offerings of the college.

M.Sci. 4990. Georgia Internship Program

Credit to be arranged. Prerequisite: consent of college.

Broadens the scope of the college curriculum by offering students a community-based learning experience which stresses the completion of a specific task.

M.Sci. 4991-2-3. Special Problems

Credit to be arranged.

The special project is designed to provide the student an opportunity to apply his or her full training to the analysis of an applied or theoretical problem. To register, the student must obtain the written approval of the associate dean and of the sponsoring professor.

M.Sci. 6010. Analytical Methods in Management

3-0-3.

Introduction to matrix algebra and calculus. Emphasis on formulating and solving problems in management and economics.

M.Sci. 6020. Quantitative Methods: Probability

3-0-3. Prerequisite: M.Sci. 6010 or its equivalent (established by passing a waiver examination).

This first of three core courses focuses on probability and its use to structure decision problems. Other topics are descriptive statistics, interactive computing and file management, and BASIC programming.

M.Sci. 6021. Quantitative Methods: Statistics

3-0-3. Prerequisite: M.Sci. 6020 or its equivalent.

This second of three core courses includes inferential statistics and decision analysis. Topics include hypothesis tests, forecasting, regression, Bayesian methods, utility theory, and simulation.

M.Sci. 6022. Quantitative Methods: Optimization

3-0-3.

This third of three core courses introduces formal analysis of management and economic decision problems through the use of optimization methods. Includes linear programming and mixed integer programming.

M.Sci. 6051. Computer Simulation of Management Problems

3-0-3. Prerequisite: M.Sci. 6050 or equivalent.

Techniques of simulating general management decisions utilizing information from the areas of marketing, production, finance and industrial relations.

M.Sci. 6055. Management Information Systems

2-2-3. Prerequisite: M.Sci. 6020, 6021 or equivalent.

Application of systems analysis and computer technology to the design and implementation of information systems to support managerial decisions.

M.Sci. 6101. Regression Analysis

3-0-3. Prerequisite: M.Sci. 6021 or equivalent.

Theory and applications of elementary multiple regression analysis in a management framework.

M.Sci. 6102. Multivariate Analysis.

3-0-3. Prerequisite M.Sci. 6101.

Multivariate statistical analysis with applications in business and economics.

M.Sci. 6105. Game Theory

3-0-3.

Models of nondeterministic decision situations. General finite games in extensive and normal forms, utility indicators, matrix games, mixed extensions, the fundamental theorem and computational techniques.

M.Sci. 6106. Applications of General Decision Theory in Management and Economics

3-0-3.

Risk games, statistical games, Bayes and min-max strategies, principle of choice problem, no data and data variants. Applications in management and economics.

M.Sci. 6201. Stochastic Optimization

3-0-3. Prerequisite: Math. 4221 or M.Sci./Math 6750.

Optimization of sequential decision models for production, congestion, inventory, fisheries and

other contexts. Myopic policies, Markov decision processes and monotone policies.

M.Sci. 6410. Mathematical Programming

3-0-3. Prerequisite: M.Sci. 6010 and consent of college.

Survey of major results in linear programming, goal programming, and integer programming. Includes cases which illustrate issues of practical implementation.

M.Sci. 6411. Seminar in Mathematical Programming

3-0-3. Prerequisite: M.Sci. 6410.

Student research and/or in-depth study of recent literature on theory and application of mathematical programming in management and economics.

M.Sci. 6750. Stochastic Models in Management Science

3-0-3. Prerequisite: Introductory probability (Math. 4215) and Calculus (Math. 2308).

Stochastic process models for managerial contexts including production, congestion, cash flow, fisheries and passenger reservations. Processes include birth and death, renewal and Markov. Also listed as Math 6750.

M.Sci. 8401-2-3-4-5-6. Special Topics

1-0-1 through 6-0-6 respectively. Prerequisite: consent of college.

Topics of current interest in the field of management science.

M.Sci. 8501-2-3-4. Special Problems

Credit to be arranged. Prerequisite: consent of college.

Provides project work experience in the field of management science.

MANAGEMENT SCIENCE

See Management.

MATHEMATICS

Math. 1307. Calculus I

5-0-5. Prerequisite: entrance algebra and trigonometry.

The derivative, derivatives of elementary functions, applications of derivatives. Credit is not allowed for both Math. 1307 and Math. 1712 except in I.M. degree programs.

Text: at the level of Thomas and Finney, *Calculus and Analytic Geometry*.

Math. 1308. Calculus II

5-0-5. Prerequisite: Math. 1307.

Integral calculus, notion of integral, definite and indefinite integrals, techniques of integration, approximate methods, improper integrals. Credit is not allowed for both Math. 1308 and Math. 1713 except in Mgt. degree programs.

Text: at the level of Thomas and Finney, *Calculus and Analytic Geometry*.

Math. 1309. Calculus III

5-0-5. Prerequisite: Math. 1308.

Complex numbers; first and second order differential equations, applications in oscillations; geometry in E^n ; vectors, matrices, systems of linear algebraic equations.

Text: at the level of Thomas and Finney, *Calculus and Analytic Geometry*.

Math. 1317-8-9. Honors Calculus I, II, III

5-0-5 each.

The topics covered parallel those of Math. 1307-8-9, with a treatment somewhat more intensive and rigorous. Credit is not allowed for both an honors calculus course and the corresponding regular calculus course.

Math. 1710. College Algebra and Trigonometry

5-0-5. Prerequisite: entrance algebra. No credit toward graduation for engineering or science degrees.

The function concept, exponential, logarithmic and trigonometric functions, theory of equations including trigonometric equations.

Text: at the level of Keedy and Bittinger, *Algebra and Trigonometry*.

Math. 1711. Mathematics for Management I

5-0-5. Prerequisite: entrance algebra.

Sets, counting techniques, binomial theorem, finite sequences and series, probability on finite sample spaces, functions, equations and graphs, basic linear algebra. Credit is not allowed for both Math. 1711 and 2010.

Texts: at the level of Baxter and Sloyer, *Calculus with Probability for the Life and Management Sciences* and Lipschutz, *Theory and Problems of Finite Mathematics*.

Math. 1712. Mathematics for Management II
5-0-5. Prerequisite: Math. 1711.

Continuous functions and limits, optimization, exponential functions and logarithms, inverse functions, derivatives, definite and indefinite integrals. Credit is not allowed for both Math. 1712 and Math. 1307 except in I.M. degree programs.
Text: at the level of Baxter and Sloyer, *Calculus with Probability for the Life and Management Sciences*.

Math. 1713. Mathematics for Management III
5-0-5. Prerequisite: Math. 1712 or 1307 and 1308.

Integration techniques, improper integrals and normal density functions, Taylor polynomials and the Poisson process, multivariate calculus. Credit is not allowed for both Math. 1713 and Math. 1308 except in I.M. degree programs.
Text: at the level of Baxter and Sloyer, *Calculus with Probability for the Life and Management Sciences*.

Math. 2010. Finite Mathematics

5-0-5. Prerequisite: Math. 1712 or 1307.
Elements of logic, set theory, probability and linear algebra, with an introduction to convex sets and linear programming. Credit not allowed for both Math. 2010 and 1711.

Math. 2020. Introduction to Set-Theoretic Concepts

3-0-3. Prerequisite: Math. 1308 or 1713.
Algebra of sets, cartesian products, relations, equivalence relations, functions, sequences, mathematical induction, equipotence of sets, partially ordered sets.

Text: at the level of Lin and Lin, *Set Theory*.

Math. 2307. Calculus IV

5-0-5. Prerequisite: Math. 1309.
Vector calculus, linear algebra, linear independence, bases, eigenvalues and eigenvectors, partial derivatives, differentiable functions, gradient, maximum and minimum problems.

Text: at the level of Williamson and Trotter, *Multivariable Mathematics*.

Math. 2308. Calculus V

5-0-5. Prerequisite: Math. 2307.
Multiple integration, line and surface integrals, integral theorems and applications to transport theory; infinite series, Taylor's theorem.
Text: at the level of Thomas and Finney, *Calculus and Analytic Geometry*.

Math. 2309. Differential Equations

5-0-5. Prerequisite: Math. 2308.
Linear differential equations and applications in the engineering and the natural sciences, systems of linear differential equations, series solu-

tions, simple nonlinear equations. Credit is not allowed for both Math. 2309 and 3308 or 3709.

Text: at the level of Ross, *Introduction to Ordinary Differential Equations*.

Math. 2317-8. Honors Calculus IV, V
5-0-5 each.

A continuation of Math. 1317, 1318, 1319. The coverage parallels that of Math. 2307-8.

Math. 3110. Introduction to Higher Algebra
3-0-3. Prerequisite: Math. 2307 or 1713.

Vector spaces, matrices, systems of linear equations, linear transformations and matrices, change of basis, characteristic roots and vectors, quadratic forms and diagonalization.

Text: at the level of O'Nan, *Linear Algebra*.

Math. 3215. Problems in Probability and Statistics

5-0-5. Prerequisite: Math. 2308 or 1713.
Problem-oriented introduction to probability with applications (see Math. 4215), including models and problems in statistical inferences. Credit is not allowed for both Math. 3215 and 4215.

Text: at the level of Meyer, *Introductory Probability and Statistical Applications*.

Math. 3308. Differential Equations

5-0-5. Prerequisite: Math. 2308.
Differential equations with linear algebra, matrix treatment of linear systems, characteristic roots, exponential matrix function, series method stressing equations of Bessel and Legendre.
Text: at the level of Rabenstein, *Elementary Differential Equations with Linear Algebra*.

Math. 3640. Introduction to Scientific Computing

3-0-3. Prerequisite: Math. 2307, and knowledge of computer programming.
Solution of problems in economics, science and technology employing algorithms for linear and nonlinear equations, integration and ordinary differential equations. Student use of computers emphasized.

Math. 3709. Mathematics for System Engineering

3-0-3. Prerequisite: Math. 2308.
Techniques for solving linear differential equations (and systems) with constant coefficients, e.g. with Laplace transform. Credit is not allowed for Math. 3709 and 2309 or 3308.
Text: at the level of Bronson, *Differential Equations*.

Math. 3710. Introduction to Statistics

5-0-5. Prerequisite: Math. 1308 or 1712.
Basic concepts and tools of statistical analysis

as used in data analysis and inference in the behavioral, life managerial, and physical sciences.

Text: at the level of Walpole, *Introduction to Statistics*.

Math. 3716. Statistics for Management Science

5-0-5. Prerequisites: Math. 2307 and Math. 3215.

Unified approach to statistical inferences through decision methods, and to regression and experimental design through least squares. Topics are introduced with discipline-oriented problems.

Text: at the level of Walpole, *Introduction to Statistics*.

Math. 4010. Introduction to Graph Theory and Combinatorial Mathematics

3-0-3. Prerequisite: entrance algebra.
Fundamental concepts, results and applications of graph theory and combinatorics, including trees, circuits, cutsets, incidence and adjacency matrices, planarity, coloring problems and basic combinatorial tools.

Text: at the level of Wilson, *Introduction to Graph Theory*.

Math. 4038. Mathematical Logic

3-0-3. Prerequisite: Math. 2308 or 1713.
The propositional and predicate calculi, developed as formal systems of symbol manipulation, with attention to the related decision problems, recursive functions and automata.
Text: at the level of Stoll, *Introduction to Set Theory and Logic*.

Math. 4101. Introduction to Abstract Algebra I
3-2-4. Prerequisite: Math. 2308.

An introduction to basic algebraic systems with emphasis on groups, rings and fields.
Text: at the level of Herstein, *Topics in Algebra*.

Math. 4102. Introduction to Abstract Algebra II

3-0-3. Prerequisite: Math. 4101.
A continuation of Math. 4101 with emphasis on modules, polynomial rings and linear associative algebras.
Text: at the level of Herstein, *Topics in Algebra*.

Math. 4140. Theory of Groups

3-0-3. Prerequisite: Math. 4101.
Basic topics from group theory including some representation theory.
Text: at the level of Rotman, *The Theory of Groups, an Introduction*.

Math. 4215. Introduction to Probability

3-0-3. Prerequisite: Math. 2308 or 1713.
Introduction to probability theory with applications, discrete and nondiscrete distributions, moments, laws of large numbers, central limit theorem with applications. Credit is not allowed for both Math. 4215 and 3215.
Text: at the level of Meyer, *Introductory Probability and Statistical Applications*.

Math. 4220. Elementary Discrete-Time Stochastic Processes

3-0-3. Prerequisite: Math. 3215 or Math. 4215.
Development of random walk, waiting-time processes and other stochastic processes through a problem-oriented approach. Methods of solution include counting techniques, recurrence relations and generating functions.

Text: at the level of Feller, W., *An Introduction to Probability Theory and Its Applications*, Vol. I.

Math. 4221. Probability with Applications

3-0-3. Prerequisite: Math. 3215 or 4215.
Introduction to discrete-time Markov chains, with applications.
Text: at the level of Hoel, Port and Stone, *Introduction to Stochastic Processes*.

Math. 4222. Probability with Applications

3-0-3. Prerequisite: Math. 4221. Prerequisite or corequisite: Math. 3110.
Introduction to continuous-time Markov chains, with applications.
Text: at the level of Karlin, *A First Course in Stochastic Process*.

Math 4225. Computer Usage in Probability

3-0-3. Prerequisite: Math. 3215 or Math. 4215 and I.C.S. 1700.
Study of probability distributions, limit laws and applications through the use of digital computer. Probability (Monte Carlo) methods applied to deterministic problems.

Math 4230. Analysis of Probability Distributions

3-0-3. Prerequisite: Math 2308 and Math. 3215 or equivalent.
Theory and methods in probability are developed. Important distributions, transform methods, multivariate distributions and limit theorems are introduced.

Math. 4241. Mathematical Statistics

3-0-3. Prerequisite: Math. 2308 and either 3215 or 4215.
Unified approach to statistical estimation and testing of hypotheses, including introduction to Bayesian methods. Exact and asymptotic sampling distributions. Applications.

Text: at the level of Hoel, Port and Stone, *Introduction to Statistical Theory*.

Math. 4242. Mathematical Statistics

3-0-3. Prerequisite: Math. 4241.

Unified approach to regression analysis, analysis of variance and experimental design, making use of linear algebra and generalized inverses. Applications.

Text: at the level of Graybill, *Theory and Application of the Linear Model*.

Math. 4245. Computer Usage in Statistics

3-0-3. Prerequisite: Math. 4241 and I.C.S. 1700 or equivalent.

Mathematical description of statistical models and the use of statistical computer routines, especially SPSS. Statistical packages in data analysis, including data description, t-tests and one way ANOVA, plots and histograms, frequency tables, regression, ANOVA, ANACOVA, and non-parametric procedures.

Text: Appropriate statistical package manuals.

Math. 4251. Nonparametric Statistics

3-0-3. Prerequisite: Math. 4241.

Goodness-of-fit tests, rank tests, tests of association, location tests, scale tests, asymptotic theory including use of Pitman efficiency.

Text: at the level of J. D. Gibbons, *Nonparametric Statistical Inference*.

Math 4280. Elements of Information Theory

3-0-3. Prerequisite: Math. 3215 or 4215.

A mathematical approach to information theory, primarily through probability in finite sample spaces. Coding theorem for discrete memoryless channels. Decision schemes, Shannon's theorem.

Text: at the level of Ash, *Information Theory*.

Math. 4281. Elementary Decision Theory

3-0-3. Prerequisite: Math. 4241.

Mathematical approach to decision theory. Bayesian and minimax strategies in response to statistical uncertainty. Applications to mathematical statistics.

Text: at the level of Ferguson, *Mathematical Statistics: A Decision Theoretic Approach*.

Math. 4282. Introduction to Stochastic Processes

3-0-3. Prerequisite: Math. 3215 or 4215.

Second-order stochastic processes, especially stationary and weakly stationary processes. Gaussian processes. Spectral analysis.

Text: at the level of Yaglom, *Theory of Stationary Random Functions*.

Math. 4283. Introduction to Game Theory

3-0-3. Prerequisite: one of Math. 2010, 3110, 4580 or consent of department.

Introduction to game theory with emphasis on zero-sum two person games, economic applications, connections with linear programming and decision functions.

Text: at the level of Dresher, *Games of Strategy*.

Math. 4301. Finite-dimensional Vector Spaces

3-2-4. Prerequisite: Math. 2308.

A study of finite-dimensional vector spaces treating linear transformations, algebra of operators, inner product spaces and normed linear spaces.

Text: at the level of Stoll, Wong, *Linear Algebra*.

Math. 4302. Applications of Finite-Dimensional Vector Spaces

3-0-3. Prerequisite: Math. 4301.

Applications of Math. 4301 with topics selected from the areas of convex sets, positive matrices, quadratic forms, linear differential equations and generalized inverses.

Math. 4308. Ordinary Differential Equations

4-0-4. Prerequisite: Math. 2309 or 3308, Math. 3110 and either 4311 or 4391.

Systems of differential equations, linear systems and phase space analysis, existence theory, stability of linear systems, Liapunov theorems, stability of automatic control systems.

Text: at the level of Brauer and Nohel, *Qualitative Theory of Ordinary Differential Equations*.

Math. 4311. Introduction to Analysis I

3-2-4. Prerequisite: Math. 2309 or 3308 or equivalent.

Real numbers, order completeness, normed vector spaces and notions of completeness and compactness, functions and continuity, sequences and series.

Text: at the level of Bartle, *The Elements of Real Analysis*.

Math. 4312. Introduction to Analysis II

3-2-4. Prerequisite: Math. 4311.

Limits of functions, differentiation of functions of one variable, Riemann-Stieltjes integral, improper integrals, absolute and conditional convergence, integrals of sequences and series.

Text: at the level of Bartle, *The Elements of Real Analysis*.

Math. 4313. Introduction to Analysis III

3-2-4. Prerequisite: Math. 4312.

Differentiation in \mathbb{R}^n , local inverse function theorem, implicit function theorem, extremum

problems and Lagrange multipliers, integration in \mathbb{R}^n , change of variables in multiple integrals.

Text: at the level of Bartle, *The Elements of Real Analysis*.

Math. 4320. Complex Analysis

3-0-3. Prerequisite: Math. 2309 or 3308.

Topics from complex function theory, including contour integration and conformal mapping.

Text: at the level of Churchill, *Complex Variables with Applications*.

Math. 4347. Introduction to Partial Differential Equations

3-0-3. Prerequisite: Math. 2309 or 3308.

Second-order linear differential equations, including the wave equation. Properties of parabolic and elliptic equations. The method of separation of variables. Fourier series. Green's function.

Text: at the level of Weinberger, *A First Course in Partial Differential Equations*.

Math. 4348. Introduction to Partial Differential Equations

3-0-3. Prerequisite: Math. 4347.

A continuation of Math. 4347. Sturm-Liouville theory and general Fourier expansions, Green's functions, elementary theory of analytic functions of a complex variable.

Text: at the level of Weinberger, *A First Course in Partial Differential Equations*.

Math. 4349. Introduction to Partial Differential Equations

3-0-3. Prerequisite: Math. 4348.

A continuation of Math. 4347, 4348. Applications of complex variables, theory and application of Fourier and Laplace transforms. Approximation methods.

Text: at the level of Weinberger, *A First Course in Partial Differential Equations*.

Math. 4391. Topics in Advanced Calculus I

3-0-3. Prerequisite: Math. 2308.

Partial differentiation, applications of partial differentiation, infinite series, improper integrals, uniform convergence.

Text: at the level of Taylor and Mann, *Advanced Calculus*.

Math. 4392. Topics in Advanced Calculus II

3-0-3. Prerequisite: Math. 4391.

Continuation of Math. 4391. Main topic is integration and applications. Also, Riemann, Stieltjes, multiple, line and surface integrals and the gamma function.

Text: at the level of Taylor and Mann, *Advanced Calculus*.

Math. 4431. Introductory Topology

3-0-3. Prerequisite: Math. 4311 or consent of school.

This course provides background for use of topological methods in analysis. Metric spaces. Continuous transformation. Topological spaces.

Text: at the level of Kasriel, *Undergraduate Topology*.

Math. 4432. Introduction to Algebraic Topology

3-0-3. Prerequisite: Math. 4431 and 4101 or 4301.

Introduction to algebraic methods in topology. Includes homotopy, the fundamental group, covering spaces, simplicial complexes. Applications to fixed point theory and graph theory.

Text: at the level of Singer and Thorpe, *Elementary Topology and Geometry*.

Math. 4441. Differential Geometry

3-0-3. Prerequisite: Math. 2308.

The theory of curves and surfaces, including the first and second fundamental forms of a surface and topics related to them.

Text: at the level of O'Neil, *Elementary Differential Geometry*.

Math. 4580. Linear Programming

3-0-3. Prerequisite or corequisite: Math. 2308.

Mathematical structure of the linear programming problem. Requisite topics in linear algebra. Simplex method. Applications.

Text: at the level of Smythe and Johnson, *Introduction to Linear Programming*.

Math. 4581. Advanced Engineering Mathematics

3-0-3. Prerequisite: Math. 2309 or 3308.

The Laplace transform and its properties, applications to physical systems involving the solution of ordinary and partial differential equations.

Text: at the level of Churchill, *Operational Mathematics*.

Math. 4582. Advanced Engineering Mathematics

3-0-3. Prerequisite: Math. 2309 or 3308.

Fourier series, boundary value problems for partial differential equations, applications of Legendre polynomials and Bessel functions.

Text: at the level of Powers, *Boundary Value Problems*.

Math. 4583. Vector Analysis

3-0-3. Prerequisite: Math. 2308.

Vector calculus. Line, surface and volume integrals. Gradient, divergence, curl. Theorems of Green, Gauss and Stokes. Curvilinear coordinate systems. Introduction to tensors.

Text: at the level of Davis, Snider, *Introduction to Vector Analysis*.

Math. 4584. Mathematical Methods in Continuum Mechanics

3-0-3. Prerequisite: Math. 2308.

An elementary tensorial treatment of various geometric and mechanical concepts needed in the study of hydrodynamics, elasticity and plasticity.

Text: at the level of Prager, *Introduction to Mechanics of Continua*.

Math. 4591. Introduction to Mathematical Optimization

3-0-3. Prerequisite: Math. 2308.

Introduction to various linear and nonlinear optimization problems in finite-dimensional spaces. Mathematical properties of the objective function will be examined and appropriate algorithms developed.

Text: at the level of Cooper and Steinberg, *Introduction to Methods of Optimization*.

Math. 4640. Scientific Computing I

3-0-3. Prerequisite: Math. 2308, and knowledge of computer programming.

Topics include finding zeros of functions, direct and iterative methods for solving linear systems of equations, polynomial interpolation and numerical integration including Romberg and adaptive methods. Math. 4640 replaces 4643.

Math 4641. Scientific Computing II

3-0-3. Prerequisite: Math 4640 or consent of school.

Topics covered include solution of ordinary differential equations, non-linear systems of equations, eigenvalue problems, least squares and spline approximations. Math 4641 replaces 4644.

Math. 4643. Numerical Analysis I

See Math. 4640.

Math. 4644. Numerical Analysis II

See Math. 4641.

Math 4790. Intensive Review of the Elementary Calculus

10-6-9 audit basis only. Prerequisite: consent of school and student's adviser.

Refresher course for beginning graduate students with calculus background who have been away from academic work for considerable time. Review of calculus through sophomore level.

Math. 4800. Special Topics

3-0-3. Prerequisite: consent of school

This course enables the School of Mathematics to comply with requests for courses in special topics. Given upon sufficient demand.

Math. 4805. Special Topics

5-0-5.

Math. 4999. Reading or Research

1 to 3 credits. Prerequisite: junior standing or above, consent of school.

Pass/fail basis only. Not more than seven hours can be counted toward bachelor's degree. At most three hours can be counted as mathematics elective.

Math. 6121. Modern Abstract Algebra I

3-0-3. Prerequisite: Math. 4101, 4301.

An introduction to algebraic systems with emphasis on group theory.

Text: at the level of Lang, *Algebra*.

Math. 6122. Modern Abstract Algebra II

3-0-3. Prerequisite: Math. 6121.

Rings, ideals and related concepts, field theory, unique factorization.

Text: at the level of Lang, *Algebra*.

Math. 6123. Modern Abstract Algebra III

3-0-3. Prerequisite: Math. 6122.

Concept of the total matrix algebra. Introduction to linear associative algebras.

Text: at the level of Lang, *Algebra*.

Math. 6232. Probabilistic Methods in Sequential Decision Theory

3-0-3. Prerequisite: Math. 4221 or the equivalent.

Development of results in sequential decision theory through probabilistic concepts and reasoning. Emphasis on application of Markov chain and martingale theories.

Math. 6241-2-3. Probability I, II, III

3-0-3 each. Prerequisite: Math. 6310 or equivalent.

This sequence develops the probability basis requisite in modern statistical theories and stochastic processes. It includes a selection of topics from measure and integration theory, distribution functions, convergence concepts, Fourier integrals and central limit theory, conditional distributions and dependence and random analysis.

Math. 6261. Mathematical Statistics

3-0-3. Prerequisite: Math. 4241.

Detailed non-measure-theoretic treatment of minimum variance unbiased estimation and hypothesis testing, including UMP, UMP unbiased, best invariant and locally best tests.

Text: at the level of Ferguson, *Mathematical Statistics*.

Math. 6307-8-9. Ordinary Differential Equations

3-0-3 each. Prerequisite: Math. 3110, 4313.

This sequence develops the qualitative theory

for systems of ordinary differential equations. Initial-value problems for systems and nth order equations. Differential inequalities. Stability of linear and perturbed linear systems, Liapunov functions. Boundary-value problems. Periodic solutions and behavior near periodic orbits. Oscillation and comparison theorems. Asymptotic behavior.

Math. 6310. Real Analysis

5-0-5. Prerequisite: Math. 4311, 4312, 4313.

Measures and measurable functions. Lebesgue integration. Convergence theorems for integrable functions. L^p spaces. Product measures and Fubini's theorem. Randon-Nikodym theorem. Absolute continuity and differentiation.

Math. 6315. Real Analysis II

3-0-3. Prerequisite: Math. 6310.

Such topics as structure of the real numbers, axiom of choice, Zorn's Lemma, Hamel basis, Baire category theorem, Stone-Weierstrass theorem and the Daniell integral.

Math. 6320. Complex Analysis

5-0-5. Prerequisite: Math. 4311, 4312, 4313, 4320.

Analytic functions, harmonic functions, conformal mapping, Cauchy's theorem, Cauchy's formulas for derivatives, maximum principle, power series, argument principle, residue theory, contour integration, analytic continuation, applications.

Math. 6325. Complex Analysis II

3-0-3. Prerequisite: Math. 6320.

Analytic continuation, product and partial fraction representation of meromorphic functions, Mittag-Leffler theorem, conformal mapping, Schwarz-Christoffel transformations, application to Dirichlet's Problem, normal families, Riemann mapping theorem.

Math. 6330. Functional Analysis

5-0-5. Prerequisite: Math. 4301, 4311, 4312, 4313.

Hilbert and Banach spaces, strong and weak convergence, Riesz representation theorem, Hahn-Banach theorem, linear operators, open mapping and closed graph theorems, compact operators, spectral theory.

Math. 6335. Functional Analysis II

3-0-3. Prerequisite: Math. 6330.

Elements of nonlinear functional analysis, fixed point theorems; locally convex linear topological spaces, Krein Milman theorem; spectral decomposition theorems, Banach algebras.

Math. 6341. Partial Differential Equations I

3-0-3. Prerequisite: Math. 4311, 4312, 4313, 4582.

Classification of partial differential equations, canonical forms, well posed problems, wave equation in R^n , Huygen's principle, potential equation, heat equation, strong maximum principles, fundamental solutions.

Math. 6342. Partial Differential Equations II

3-0-3. Prerequisite: Math. 6341.

Existence theory for elliptic equations, single and double layer potentials, Schwarz alternating procedure, subharmonic functions, weak solutions in a Sobolev space, regularity of weak solutions.

Math. 6343. Partial Differential Equations III

3-0-3. Prerequisite: Math. 6342.

Finite dimensional approximation of weak solutions, existence theory for evolution equations, semigroups, fundamental solutions, regularity of solutions, nonlinear evolution equations.

Math. 6431-2-3. General Topology I, II, III

3-0-3 each. Prerequisite: Math. 4431 or consent of school

Bases and subbases, filters, nets and convergence, continuous functions, separation axioms, connectedness, separability, compactness, sup and weak topologies, products and quotients, compactifications and other embeddings, completeness and Baire category, uniform spaces, metrization, function spaces, topological groups.

Text: at the level of Wilansky, *Topology for Analysis*.

Math. 6441-2-3. Algebraic Topology I, II, III

3-0-3. Prerequisite: Math. 4431, 4101 and 4301 or consent of school.

Introduction to homological algebra, Cech and singular homology and cohomology theories. Applications to fixed points of maps, spheres, invariance of domain, etc., homotopy, the fundamental group, covering spaces. Introduction to sheaf theory, category theory, spectral sequences.

Text: at the level of Spanier, *Algebraic Topology*.

Math. 6510. Deterministic Models from the Physical Sciences and Technology

5-0-5. Prerequisite: Phys. 3121, Math. 4582.

Electrical, mechanical, thermal systems leading to difference equations. Lumped parameter electrical, mechanical systems leading to ordinary differential equations. Distributed-parameter systems leading to partial differential equations.

Math. 6511. Mathematical Methods of Applied Science I

5-0-5. Prerequisite: Math. 2309 or 3308 and 3110 or consent of school.

The first of three courses providing quick access to mathematical techniques important in

science and engineering. Complex variables, linear algebra, linear differential and difference equations. Credit not allowed toward graduate degrees in mathematics.

Math. 6512. Mathematical Methods of Applied Science II

5-0-5. Prerequisite: Math. 6511.

A continuation of Math. 6511. Partial differential equations, special functions, operational methods, integral transforms. Credit not allowed toward graduate degrees in mathematics.

Math. 6513. Mathematics Methods of Applied Science III

5-0-5. Prerequisite: Math. 6512 or consent of school.

Approximate methods, nonlinear problems, variational techniques. Credit not allowed toward graduate degrees in mathematics.

Math. 6520. Stochastic Models

5-0-5. Prerequisite: Math. 4222 or 4242, six hours in applied fields at the upper undergraduate level.

Formulation of stochastic models appropriate for solving specific problems of description, prediction and decision, which are posed and analyzed in the context of applied fields.

Math. 6530. Equilibrium and Optimization Models

5-0-5. Prerequisite: six hours in applied fields at the upper undergraduate level, Math. 6330 or concurrently.

Formulation of linear and nonlinear operator models to solve equilibrium or optimal state problems which are posed and analyzed in the context of applied fields.

Math. 6581. Calculus of Variations

3-0-3. Prerequisite: Math. 2309 or 3308 and 3110, 4391, or consent of school.

Constrained and unconstrained problems involving single and multiple integrals and added terms. Natural boundary conditions. Transitivity. Broken extremals. Hamilton's principle.

Math. 6582. Integral Transforms

3-0-3. Prerequisite: Math. 4582, 4320, 4391 or consent of school.

Classical Fourier, Laplace and Mellin transform theory with applications to boundary-value problems. Special attention to the judicious choice of transform. Successive use of transforms.

Math. 6583. Integral Equations

3-0-3. Prerequisite: Math 2309 or 3308 and 3110, 4391, or consent of school.

Linear integral equations and their relation to

differential equations. Hilbert-Schmidt theory. Eigenvalues. Applications.

Math. 6584. Special Functions of Higher Mathematics

3-0-3. Prerequisite: Math. 4320, 4582, or consent of school.

The gamma function, Bessel functions, spherical harmonics, orthogonal polynomials and other functions of particular interest in science and technology.

Math. 6586. Tensor Analysis

3-0-3. Prerequisite: Math. 3110, 4583, 4391 or consent of school.

Tensor algebra, covariant differentiation, Cartesian tensors, curvilinear coordinates, introduction to differential forms.

Text: at the level of Borisenko and Tarapor, *Vector and Tensor Analysis*.

Math 6587. Field Theory with Applications

3-0-3. Prerequisite: Math. 4582, 4583, or consent of school.

Solution of field equations of mathematical physics by separation of variables in spherical, cylindrical and other curvilinear coordinates with attention to advantageous choice of coordinates.

Math. 6640. Applied Computational Methods for Partial Differential Equations

3-0-3. Prerequisite: Knowledge of computer programming, familiarity with partial differential equations and elements of scientific computation.

Algorithms using finite elements for the numerical solution of steady and transient problems of engineering and science. Student computer use emphasized.

Math 6643. Numerical Linear Algebra

3-0-3. Prerequisite: Math. 4301 or consent of school.

Numerical solutions of linear equations; least squares problems, the singular value decomposition and generalized inverse; methods for determining eigenvalues including the QR algorithm.

Math. 6644. Numerical Solution of Nonlinear Equations

3-0-3. Prerequisite: Math. 4301, 4313 or consent of school.

Analysis of iterative methods for nonlinear finite and infinite dimensional equations, fixed point equations, Newton's method, gradient related methods, update methods, continuation methods.

Math. 6645. Numerical Approximation Theory

3-0-3. Prerequisite: Math. 4312 or consent of school.

Theoretical and computational aspects of polynomial, rational and spline approximation, including Chebyshev and least squares approximation, linear methods of approximation, B-splines, mesh selection.

Math. 6646. Numerical Methods for Ordinary Differential Equations

3-0-3. Prerequisite: Math. 4313, Math. 3308 or consent of school.

Single and multi-step methods for initial value problems, error and stability analysis, implicit methods for stiff problems, shooting methods for boundary value problems.

Math. 6647. Theory of Numerical Methods for Partial Differential Equations

3-0-3. Prerequisite: Math. 4313, Math. 4347, Math. 4301.

Finite difference and finite element approximations for elliptic and parabolic boundary value problems, error analysis for projection methods, characteristic methods for hyperbolic systems, stability analysis.

Math. 6750. Stochastic Models in Management Science

3-0-3. Prerequisite: Math. 4215 and Math. 2308.

Stochastic process models for managerial contexts including production, congestion, cash flow, fisheries and passenger reservations. Processes include birth and death, renewal and Markov. Also listed as M.Sci. 6750.

Math. 7000. Master's Thesis

Math. 7121-23. Advanced Topics in Algebra

3-0-3 each. Prerequisite: Math. 6121, 6122, 6123 or consent of school.

Courses directed toward research in algebra. Areas of current research interests include homological algebra, finite groups, semi-groups, loop theory.

Math. 7241-2-3. Studies in Advanced Probability and Statistics

3-0-3 each. Prerequisite: Math. 6241, 6242, 6243 or consent of school.

Courses organized around recent broad advances in probability and statistics basic to research in these fields, content of courses varying from year to year. Typical courses would emphasize stochastic processes, ergodic theory, limit laws of probability, statistical decision theory, theories of estimation and hypothesis testing, etc.

Math. 7307-8-9. Advanced Problems in Ordinary Differential Equations

3-0-3 each. Prerequisite: Math. 6307, 6308, 6309 or consent of school.

Courses directed toward research in differential equations, the content varying from year to year. Representative topics include singular boundary-value problems, asymptotic solutions of differential equations, differential equations containing a large parameter, Poincare-Liapounov stability theory and differential equations in the large.

Math. 7311-2-3. Advanced Topics in Real Analysis

3-0-3 each. Prerequisite: Math. 6310 or consent of school.

Courses directed toward research in real analysis and related areas, the topics varying from year to year. Topics will be selected from areas as Hilbert space theory, theory of distributions, abstract harmonic analysis, ergodic theory, Denjoy and Perron integrals.

Math. 7321-2-3. Advanced Problems in Complex Variables

3-0-3 each. Prerequisite: Math. 6320 or consent of school.

Courses directed toward research in complex variables. Representative topics include topics from functions of several complex variables, conformal mapping.

Math. 7431-2-3. Advanced Topics in Topology

3-0-3 each. Prerequisite: consent of school.

The course content will vary from year to year. Topics selected from topological groups, algebraic topology, mapping theory, topological analysis, dimension theory, fixed point theory.

Math. 7501-2-3. Methods of Applied Mathematics

3-0-3 each. Prerequisite: consent of school.

Topics in a particular year may include some or all of variational techniques, asymptotic methods, differential operators of mathematical physics. Fourier transforms, nonlinear and singular integral equations.

Math. 7999. Preparation for Doctoral Examinations

Credit to be arranged. Prerequisite: consent of adviser.

Audit only.

Math. 8001-2-3. Seminar

1-0-0 each.

Math. 8101-11-21-31-41-51. Special Topics

1-0-1. Prerequisite: consent of school.

These courses enable the School of Mathematics to comply with requests for courses in selected topics.

Math. 8102-12-22-32-42-52. Special Topics

2-0-2.

Math. 8103-13-23-33-43-53. Special Topics
3-0-3.

Math. 8104-14-24-34-44-54. Special Topics
4-0-4.

Math. 8105-15-25-35-45-55. Special Topics
5-0-5.

Math. 8501-8599. Special Problems
Credit to be arranged. Prerequisite: consent of adviser.

Math. 9000. Doctoral Thesis

MECHANICAL ENGINEERING

M.E. 1001. Introduction to Mechanical Engineering
1-0-1. Prerequisite: Math. 1307.

Survey of the field to acquaint the student with the profession, nature, function and working tools, curriculum and topic orientation, engineering in a social context.

M.E. 1110. Creative Decisions and Design
2-3-3.

Basic concepts for creative decisions in engineering problem solving and design. Exposure to practicing engineers, their industries, problems and accomplishments. Field trips.

M.E. 1750. Introduction to Bioengineering
3-0-3.

Aspects of science and technology pertinent to bioengineering. Cross-listed with A.E. 1750, E.E. 1750, E.S.M. 1750.

M.E. 2212. Materials Science
2-0-3. Prerequisite or corequisite: Math. 2309, Phys. 2123.

Mechanical behavior, elastic and plastic properties, annealing of cold-worked materials leading from atomic concepts, crystallography and relation of crystal defects to properties.

M.E. 3016. Computer Applications
2-3-3. Prerequisite: Math. 2309.

Organization and application of digital and analog computers. Mechanical engineering problems are solved through numerical techniques. Electrical analogs and circuits are used to simulate deterministic systems. Previous experience in computer programming is recommended.

M.E. 3055. Experimental Methodology
1-3-2. Prerequisite: Math. 2309, M.E. 3322, prerequisite or corequisite: M.E. 3016.

Presentation of experimental methodology, ba-

sic instrumentation used in mechanical engineering and its calibration and use, accuracy, error and uncertainty in experimental measurements, engineering report writing.

M.E. 3113. Kinematics and Dynamics of Linkages

3-0-3. Prerequisite: E.S.M. 3201.

Kinematics and dynamics of linkages with emphasis on inertial forces. Balancing of rotating and reciprocating systems.

M.E. 3114. Dynamics of Machinery

3-0-3. Prerequisite: M.E. 3113, Math. 2309.

Dynamic modelling of systems with mechanical, fluid, thermal and/or electrical elements. Analysis including linearization, transient and frequency response, and stability. Vibration of mechanical systems.

M.E. 3181. Design of Machine Elements

3-0-3. Prerequisite: E.S.M. 3301, M.E. 3212.

Methodology and practice in designing machine components by means of integrating the general principles and empiricisms of solid mechanics, materials, metal fatigue and other disciplines.

M.E. 3183. Rational Descriptions and Engineering Design

3-0-3. Prerequisite: junior standing in engineering.

Information-theory decision analysis for engineering design with practical applications to the design of mechanical, thermal and electrical components and systems.

M.E. 3212. Materials Technology

3-3-4. Prerequisite: M.E. 2212.

Mechanical and physical properties of metallic and nonmetallic materials related to behavior under service conditions. Phase equilibria, microstructure, steels, heat treatment, annealing, fracture, fatigue, creep.

M.E. 3322. Thermodynamics

3-0-3. Prerequisite or corequisite: Phys. 2123, Math. 2308.

An introduction to thermodynamics. Thermodynamic properties, state postulate, work interactions, steady state and transient energy and mass conservations, entropy and the second law.

M.E. 3323. Thermodynamics

3-0-3. Prerequisite: M.E. 3322.

Continuation of M.E. 3322. Applications and corollaries of the second law. Availability, available energy, Carnot theorem, ideal and real gas mixtures, psychrometry, generalized thermodynamic function.

M.E. 3324. Thermodynamics

3-0-3. Prerequisite: M.E. 3323.

Continuation of M.E. 3323. Gas and vapor power cycles, vapor and gas absorption refrigeration cycles. First and second law analysis of combustion. Gibbs phase rule, chemical equilibrium.

M.E. 3342. Transport Phenomena I

3-0-3. Prerequisite: Math. 2309. Prerequisite or corequisite: M.E. 3322.

Introduction to one-dimensional heat, momentum and mass transport, developing rate equations and applying conservation principles, fundamentals of steady and transient heat conduction, including two and three dimensions, sources and extended surfaces, electrical analogies, practical applications.

M.E. 3343. Transport Phenomena II

3-0-3. Prerequisite: M.E. 3342, E.S.M. 2201. Corequisite: M.E. 3323.

Basic conservation concepts in integral form for real fluids, fluid properties and flow characteristics, fluid statics, ideal flows, Ruler, Bernoulli and Navier-Stokes equations, practical examples.

M.E. 3344. Transport Phenomena III

3-3-4. Prerequisite: M.E. 3343. Corequisite: M.S. 3324, 3055.

Compressible and incompressible flows, ducted flows, nozzles and shock waves. Radiative transport. Applications.

M.E. 3720. Thermodynamics

4-0-4. Prerequisite or corequisite: Phys. 2123, Math. 2308. Not for M.E. students.

Fundamentals of engineering thermodynamics, thermodynamic properties of matter, the concept of conservation of energy, the second law of thermodynamics and application to engineering processes.

M.E. 3726-7. Thermodynamics

4-0-4, 3-0-3. Prerequisite or corequisite: Phys. 2123, Math. 2309. Not for M.E. students.

Concepts and principles of thermodynamics. Applications to engineering systems and processes. Evaluation of thermodynamic properties of solids and polyatomic gases from statistical and quantum mechanics.

M.E. 3734. Environmental Technology in Architecture I

3-0-3. Prerequisite: Phys. 2113 or 2123. Not for M.E. students.

Needs of modern structures. Water supply and drainage. Fire protection. Environmental comfort. Design heat load calculations. Generation, trans-

port and distribution of heat with associated costs.

M.E. 3735. Environmental Technology in Architecture II

2-3-3. Prerequisite: M.E. 3734. Not for M.E. students.

Effects of solar energy. Cooling load estimates. Air conditioning systems. Delivery methods. Energy management, conservation and total energy systems. Latest topics in environmental control.

M.E. 4025. Engineering Analysis

3-0-3. Prerequisite: consent of school.

Emphasis is placed on well-ordered analytical thought processes required in the application of fundamental principles of engineering sciences to the analysis of unfamiliar engineering situations.

M.E. 4055. Experimental Engineering

1-3-2. Prerequisite: M.E. final quarter standing.

Engineering situations involving various disciplines are solved by experimental means. Students must plan experimental approach, gather data, interpret results and prepare a formal engineering report.

M.E. 4091. Seminar

1-0-1. Prerequisite: senior standing in mechanical engineering. Fall quarter only.

Civic and professional responsibilities and opportunities are brought to students by leaders in engineering, business and community affairs.

M.E. 4183. Design Theory

3-0-3. Prerequisite or corequisite: M.E. 3181.

The design process including the topics of creativity, probability, the use of statistical methods, reliability theory, decision theory, optimization and the patent system.

M.E. 4184. Design Engineering

0-6-2. Prerequisite: final quarter standing.

The design process is applied to real multidisciplinary problems by a team. Problems selected from a broad spectrum of interest areas, including biomedical, ecological, environmental.

M.E. 4185. Mechanics of Machines

3-3-4. Prerequisite: M.E. 3114, Math. 2309.

Continuation of M.E. 3114 with emphasis on the analysis of complex machines. Instrumentation and analog computer simulation of mechanism.

M.E. 4186. Biomechanical Design

3-3-4. Prerequisite: M.E. 4445 or equivalent.

Design of systems utilizing human operator dynamics in the loop. Biological systems treated

as structures, power sources and information systems, operator modeling.

M.E. 4187. Kinematic Design

2-3-3. Prerequisite: M.E. 3113 or consent of school.

The design of mechanisms to generate specified point paths or analytical functions. Graphic and analytic design methods are shown.

M.E. 4188. Cams and Gears

3-0-3. Prerequisite: M.E. 3113 or equivalent.

Selection and design of gears, spur, bevel, helical and worm gearings are treated. Cam design with applications including high speed systems.

M.E. 4204. Manufacturing Processing: Machining and Deformation

2-3-3. Prerequisite: M.E. 4212, E.S.M. 3301.

Theory and application of metal machining. Effects of work material, tool material and geometry, feed, speed and other variables are studied.

M.E. 4205. Manufacturing Processing: Casting and Joining

2-3-3. Prerequisite: M.E. 4212, E.S.M. 3301.

An intermediate level treatment of two important manufacturing operations, emphasis on the engineering and technological aspects of these processes, applications and design criteria.

M.E. 4212. Material Processes

3-3-4. Prerequisite: 9th Qtr. Standing. Consent of instructor for non-M.E. students.

Fundamentals of various techniques for solidification, working and shaping materials. Machining, casting, joining and metal forming are major topics. Laboratory practice supplements classroom treatment.

M.E. 4263. Mechanical Testing of Materials

3-3-4. Prerequisite: either Met. 3301, M.E. 3212 or consent of school.

Destructive and nondestructive test methods for metallic and nonmetallic materials. Emphasis on the significance of results and the choice of materials based on test data.

M.E. 4265. Materials Science and Engineering

3-0-3. Prerequisite: M.E. 3212.

Advanced studies of metals, polymers, ceramics. Atomic and molecular structure, crystal binding, defects, relationship of properties to microstructures. Phase equilibria, strengthening, failure, steel constituents, hardenability.

M.E. 4318. Thermal Systems Analysis and Design

4-0-4. Prerequisite: M.E. 3324, 4344, 4183; I.Sy.E. 4725.

Analysis, design, and optimization of thermal

systems and components with examples from such areas as power generation, refrigeration, and propulsion. Energy conservation schemes, total energy systems and their characteristics.

M.E. 4320. Internal Combustion Engines

3-3-4. Prerequisite: M.E. 3324, 3343.

Principles, practice and characteristics of internal combustion engines with experimental laboratory in engine testing and performance.

M.E. 4321. Principles of Air Conditioning

3-3-4. Prerequisite: M.E. 3324, 4344 or consent of school.

Psychrometric principles. Thermal comfort. Load estimates. Environmental control. System design using load wedge and supply area concepts. Experiments to determine components and system performance.

M.E. 4322. Power Plant Engineering

3-3-4. Prerequisite: M.E. 3324, 4344 or consent of school.

Steam and gas turbine power cycles. Modern power plants. Combined power plants. Energy and availability analysis. Economics of power generation. Design problems and field trips.

M.E. 4326. Principles of Turbomachinery

3-0-3. Prerequisite: M.E. 3344 or consent of school.

Head, flow and power relationships for turbomachines and their systems. Design of impellers and casings for various types of compressors, turbines and pumps.

M.E. 4327. Combustion and Flames

3-0-3. Prerequisite: M.E. 3324, 4344 or equivalent.

Stoichiometric and thermochemical analysis of fuel-oxidant reactions. Heat and mass transfer with chemical reaction applied to combustion of gas jets, solid and liquid fuels.

M.E. 4328. Elements of Rocket Systems

3-0-3. Prerequisite or corequisite: M.E. 4344.

Basic elements, ballistics and technical problems associated with the design of propulsion systems for solid and liquid propellant rockets are studied.

M.E. 4329. One-Dimensional Compressible Flow

3-0-3. Prerequisite or corequisite: M.E. 4344.

Fundamentals of one-dimensional steady and unsteady compressible flows. Isentropic flows, flows with friction and heat transfer and with shocks are examined.

M.E. 4331. Refrigeration

3-0-3. Prerequisite: M.E. 3324.

Refrigeration cycles and systems. Balanced

design concepts in selecting components. System performance at off-design conditions. Heat pumps.

M.E. 4339. Gas Turbines

3-0-3. Prerequisite: M.E. 3324, 3344.

Applications of gas turbines including limitations and advantages as compared with other prime movers. Design of compressor, combustor and turbine components.

M.E. 4343. Heating, Ventilating and Air Conditioning Design

3-0-3. Prerequisite: M.E. 4321.

Sizing of equipment for environmental control. Design of transportation and delivery systems. Energy recovery schemes. Total energy concepts and design features.

M.E. 4344. Transport Phenomena IV

3-0-3. Prerequisite: M.E. 3344.

Fundamentals of transport process applied to free and forced convection, boundary layer applications, similarity and modeling, external and internal flows, change of phase, heat exchangers. Applications.

M.E. 4347. Elements of Nuclear Power

3-0-3. Prerequisite: M.E. 4344 or equivalent.

Nuclear energy generation, fuels, materials, radiation damage, shielding and safety. Nuclear reactors: boiling water, pressurized water, gas cooled and fast breeder reactors.

M.E. 4357. Plasmas and Engineering Applications

3-0-3. Prerequisite: undergraduate thermodynamics, senior standing.

Occurrence of plasmas, review of electromagnetic theory, thermodynamics of ionized gases, equations of magnet hydrodynamics, MHD waves, channel flow, application to electric arcs, MHD energy conversion and fusion.

M.E. 4445. Automatic Control

3-0-3. Prerequisite: Math. 2309, M.E. 3016.

Analysis and modeling of linear systems and compensation of feedback controlled systems using classical methods. Hydraulic, pneumatic, thermal, electrical, nuclear, chemical and biomechanical examples.

M.E. 4449. Numerical Control of Machine Tools

3-0-3. Prerequisite or corequisite: M.E. 4445.

Study of design and operation of typical digital control systems for machine tools, including the flow of signals through the system.

M.E. 4714. Heat Transfer

3-0-3. Prerequisite: M.E. 3720, 3016 or equivalent. Not for M.E. students.

Transport processes, concepts of conduction, convection and radiation. Boundary layer analysis in convective laminar and turbulent flows. Stationary systems, including external/internal resistance criteria.

M.E. 4760. Engineering Acoustics and Noise Control I

3-0-3. Prerequisite: senior standing.

Study of acoustics related to noise and its control, acoustic terminology, wave propagation, solutions to the wave equation, instrumentation, sound fields in large and small rooms, noise legislation.

M.E. 4761. Engineering Acoustics and Noise Control II

3-0-3. Prerequisite: M.E. 4761 or equivalent.

Continuation of M.E. 4760 emphasizing techniques for the solution of noise problems. Vibration isolation, energy absorption, dissipative and reactive mufflers, enclosures, barriers, properties of materials, panel damping.

M.E. 4771. Pulp and Paper Processes I

3-0-3. Prerequisite: consent of school.

A survey of the processes in a kraft pulp mill necessary to convert raw material to sulfate pulp. Wood preparation, wood chemistry and morphology. The chemical and mechanical characteristics of kraft pulping and chemical recovery processes. Cross listed with Ch.E.

Text: Britt, *Handbook of Pulp and Paper Technology*.

M.E. 4772. Pulp and Paper Processes II

3-0-3. Prerequisite: consent of school.

The major pulping processes other than kraft pulping. General knowledge of the various factors affecting each pulping process and pulp bleaching. The unique advantages and disadvantages of each pulping and bleaching process. Cross listed with Ch.E.

Text: Britt, *Handbook of Pulp and Paper Technology*.

M.E. 4773. Paper Formation and Properties

3-0-3. Prerequisite: consent of school.

The processes in the fabrication of paper and paper products from pulp. The effects on paper properties of chemical and mechanical pre-treatment of pulp. The measurement of paper properties. Cross listed with Ch.E.

Text: Britt, *Handbook of Pulp and Paper Technology*.

M.E. 4780. Energy Conversion Engineering

3-0-3. Prerequisite: M.E. 3720 or equivalent.

Energy sources, basic principles of semiconductor, thermoelectric converters, solar power, thermionic systems, MHD, applications of these

devices for power generation, environmental effects, cost factors.

M.E. 4801-2-3-4-5. Special Topics, Mechanical Engineering

1-0-1 to 5-0-5 respectively.

Special topic offerings of current interest and not included in regular courses.

M.E. 4901 through 4912. Special Problems, Mechanical Engineering

Credit to be arranged.

Individual studies in certain specialized areas, and mathematical analyses and/or experimental investigations of problems of current interest in mechanical engineering.

M.E. 6014. Engineering Instrumentation

3-3-4. Prerequisite: M.E. 3055 or equivalent or graduate standing.

Methods and techniques of modern instrumentation in engineering research. Emphasis on analytical methods in planning and evaluation of experiments, integration of experimentation theory with practical aspects of instrumentation problems.

M.E. 6024-5. Variational Methods in Engineering

3-0-3 each. Prerequisite: M.E. 4344, E.S.M. 3302 or equivalent.

Variational methods applied to the optimization engineering systems, the formulation and approximate solution of differential equations with application to nonlinear vibration, fluid mechanics, heat transfer, hydrodynamic stability and automatic control.

M.E. 6121. Advanced Dynamics of Machinery

3-0-3. Prerequisite: consent of school.

Design-oriented dynamics. Dynamics of systems with constraints, application of virtual work—minimum potential to systems, dynamical equations of Lagrange, Hamilton.

M.E. 6122. Machine Vibration

3-0-3. Prerequisite: consent of school.

Application of dynamic theory to practical situations, natural frequencies of systems, impact, impulse and momentum, discrete and continuous system techniques, periodic and random sources.

M.E. 6125. Mechanism Synthesis I

3-0-3. Prerequisite: M.E. 4187 or equivalent.

A continuation of M.E. 4187. Advanced topics in curvature theory. Finite displacement of a plane, Burmester theory. Current developments in kinematics. Graphic and analytic design methods.

M.E. 6126. Mechanism Synthesis II: Computer Methods

2-3-3. Prerequisite: M.E. 6125.

Analog-computer simulation of linkages. Complex-number approach to linkage synthesis. Digital computation of Sandor-Freudenstein and Bloch. "Best fit" by Chebyshev polynomial approximations.

M.E. 6127. Spatial Mechanisms

3-0-3. Prerequisite: M.E. 6125.

The analysis and synthesis of three-dimensional linkages in general. Extension of the Grubler theory, number theory, special mechanisms.

M.E. 6133. Elastic Yield Design of Machine Members

3-0-3. Prerequisite: consent of school.

The methods of strain-energy, virtual work, area-moment and Castigliano's theorem are applied to the design of machine members against excessive deformation.

M.E. 6170. Engineering Design

3-6-5. Prerequisite: consent of school.

Design concepts, life design, fatigue and failure, thermal stress and the elements of optimum design are studied.

M.E. 6175. Fundamentals of Computer-Aided Design

3-0-3. Prerequisite: graduate standing, M.E. 3016, M.E. 4183 and M.E. 4445 or equivalent.

Introduction to the use of interactive computing techniques in engineering design with emphasis on interactive graphics and man-machine interaction.

M.E. 6176. Computer Aided Design Systems—Components and Techniques

3-0-3. Prerequisite: M.E. 6175 or consent of instructor.

An in-depth study of necessary hardware and software for development of computer-aided design systems with special emphasis on man-machine interface.

M.E. 6239. Materials for Design

3-0-3. Prerequisite: M.E. 4212.

Properties, behavior and selection of materials for practical design applications. Topics include effects of elastic and plastic deformation, brittle fracture, fatigue, creep and corrosion.

M.E. 6240. Advanced Materials for Design

3-0-3. Prerequisite: M.E. 6239.

Advanced studies of materials, their properties, selection and applications to high and low temperature environments. Economic, engineering and design considerations are emphasized.

M.E. 6271. Deformation of Metals

3-0-3. Prerequisite: M.E. 4212.

Advanced study of atomic structure and imperfections in crystalline solids. Topics include plastic deformation, strain hardening, annealing processes, creep, fatigue, ductile and brittle fracture.

M.E. 6272-3. Fabrication of Metals

3-0-3 each. Prerequisite: M.E. 6271.

Fabrication processes of metals including forging, rolling, extrusion, drawing, deep drawing and pressing. Frictional phenomena, slip line fields, upper bound forces, material properties and characteristics.

M.E. 6322. Thermodynamics I

3-0-3. Prerequisite: undergraduate thermodynamics.

Thorough study of the principles of macroscopic formalism of thermodynamics. Thermodynamic systems, pure substance, multi-phase mixtures, reactive systems.

M.E. 6323. Thermodynamics II

3-0-3. Prerequisite: undergraduate thermodynamics.

Microscopic thermodynamics based on classical mechanics, quantum mechanics and information theory. Prediction of macroscopic properties and system behavior from statistical considerations.

M.E. 6324. Thermodynamics III

3-0-3. Prerequisite: M.E. 6323 or equivalent.

Statistical thermodynamic calculation of properties of ideal gases, real gases, solids and gas mixtures. Kinetic theory and transport properties. Thermodynamics of special systems.

M.E. 6325. Information Theory Thermodynamics

3-0-3. Prerequisite: M.E. 6323 or consent of school.

A derivation from information theory of the fundamentals of thermodynamics and statistical mechanics. Applications to irreversible thermodynamics and the design of thermosystems.

M.E. 6332. Heat Transfer I

3-0-3. Prerequisite: M.E. 4344 or consent of school.

Conduction—steady state and transient, one and multi-dimensional geometries. Emphasis on analytical methods—exact and approximate, on numerical and graphic techniques.

M.E. 6333. Heat Transfer II

3-0-3. Prerequisite: M.E. 6332 or consent of school.

Convection—forced and free, in laminar and turbulent, internal and external flows. Analogy between momentum and heat transfer. Scaling laws and partial modeling.

M.E. 6334. Heat Transfer III

3-0-3. Prerequisite: graduate standing.

Radiation—electrodynamics, radiation optics, photon gas concept, black body radiation, surface characteristic, exchange in enclosures, radiation through continua, experimental methods.

M.E. 6338. Advanced Theory of Heat Transfer

3-0-3. Prerequisite: M.E. 6332, 6333.

Advanced mathematical methods in conduction and convection, ablation, solidification, packed and fluidized beds, condensation, boiling heat transfer, heat transfer in porous media, transient boundary layers.

M.E. 6342. Fluid Flow I

3-0-3. Prerequisite: M.E. 3343 or consent of school.

A general development of the continuity, linear and angular momentum and energy equations followed by the fundamentals of perfect fluid theory.

M.E. 6343. Fluid Flow II

3-0-3. Prerequisite: M.E. 6342 or equivalent.

Viscous flow theory including derivation of Navier-Stokes equations, a study of their general properties and their applications to creeping flow and to laminar and turbulent boundary layers.

M.E. 6344. Fluid Flow III

3-0-3. Prerequisite: M.E. 6343 or equivalent.

Turbulent flow theory, origins of turbulence, turbulent stress, mixing-length models, free turbulent flow, flow in pipes and boundary layers, statistical description of turbulence.

M.E. 6351. Direct Energy Conversion

3-0-3. Prerequisite: M.E. 3720 or equivalent.

Analysis of performance characteristics, based on thermodynamic and fluid flow principles of direct energy conversion devices such as thermionic, thermoelectrics, photovoltaic, magnetohydrodynamic, electrohydrodynamic generators and fuel cells.

M.E. 6352. Energy Conversion Systems

3-0-3. Prerequisite: M.E. 3324 or equivalent.

A study of alternative energy conversion systems and analysis of their economic and commercial performance characteristics. Comparative analysis of Otto, Diesel, Brayton, Rankine, solar and direct energy conversion systems.

M.E. 6353. Diagnostics of Combustion Gases and Plasmas

3-0-3. Prerequisite: statistical thermodynamics. Study of diagnostic techniques for combustion gases and plasmas. Review of relevant physical phenomena. Spectroscopic, interferometric, laser and probe techniques. Treatment includes latest techniques and procedures.

M.E. 6355. Combustion I

3-0-3. Prerequisite: graduate standing.

Conservation laws and constitutive equations in reactive media. Reactions kinetics, laminar and turbulent diffusion flames.

M.E. 6356. Combustion II

3-0-3. Prerequisite: M.E. 6355 or equivalent.

Combustion of liquid and solid fuels. Combustion in laminar boundary layers.

M.E. 6357. Combustion III

3-0-3. Prerequisite: M.E. 6356 or equivalent.

Combustion in turbulent boundary layers. Spontaneous ignition and explosions. Flame propagation and flammability limits.

M.E. 6360. Solar Energy Engineering

3-0-3.

Fundamentals of solar radiation, transmission and absorption. Flat plate and focusing collectors. Thermal storage. Heating and cooling of structures. Distillation. Process heat supply. Power generation.

M.E. 6370. Thermal Environmental Control

3-0-3. Prerequisite: consent of school.

Thermodynamic relations of moist air. Air conditioning processes. Environmental systems for thermal comfort. Direct and indirect contact transport processes.

M.E. 6371. Advanced Refrigeration

3-0-3. Prerequisite: consent of school.

Development of design and performance characteristics of vapor compression, absorption and several other work and heat input refrigeration cycles. Specification of desirable refrigerant properties.

M.E. 6376. Internal Combustion Engine Design

3-0-3. Prerequisite: undergraduate design, M.E. 4320 or equivalent.

Internal combustion engine design practice to accommodate challenges of application, efficiency, emissions and balance.

M.E. 6377. Internal Combustion Engines

3-0-3. Prerequisite: M.E. 6355 or equivalent.

Principles of operation of reciprocating and rotating engines including analysis of pollutant formation and methods of its control.

M.E. 6379. Turbines

3-0-3. Prerequisite: either M.E. 4339, 4326 or consent of school.

Basic fluid mechanics and thermodynamics of the expansion processes in various types of radial and axial flow turbines. Current literature is discussed.

M.E. 6383. Lubrication

3-0-3. Prerequisite: consent of school.

Hydrodynamic, hydrostatic, liquid and gas lubrication, elastohydrodynamic lubrication, lubrication properties, boundary lubrication, friction and solid lubricants are covered from fundamental development through design considerations.

M.E. 6424. Feedback Control Systems I

3-0-3. Prerequisite: graduate standing.

Linear systems. Integration of classical (root locus, frequency response) and modern (state feedback, observers) techniques. Mechanical, thermal, fluid, chemical and nuclear examples.

M.E. 6425. Feedback Control Systems II

3-0-3. Prerequisite: either M.E. 4445, 6424 or equivalent.

Discrete time and nonlinear systems. Sample data and digital control. Phase plane, describing functions and Lyapunov methods.

M.E. 6426. Feedback Control Systems III

3-0-3. Prerequisite: M.E. 6424 or equivalent.

Optimal systems. Maximum principle and dynamic programming. Quadratic linear optimization. Kalman filtering. Computational methods.

M.E. 6437-8. Digital Control Systems I and II

3-0-3, 3-3-4. Prerequisite: graduate standing or consent of school. M.E. 6437 is prerequisite for 6438:

The basic theory and techniques employed in the design of control systems for numerically controlled machine tool and digital computers.

M.E. 6439. Control System Components

2-1-3. Prerequisite: M.E. 4445 or equivalent.

The performance characteristics and the mathematical modeling of control system components, including transient and frequency response tests.

M.E. 6440. Fluid-Power Control Systems

3-0-3. Prerequisite: M.E. 4445 or equivalent.

Analysis and synthesis of control systems using liquids and gases. Dynamic characteristics and specifications of control system components, closed-loop fluid-power control systems.

M.E. 6471. Control of Engineering Processes

3-0-3. Prerequisite: M.E. 6424 or equivalent.

Large-scale computer solutions and simulation.

tion. Distributed parameter system modeling and analysis. Current interest topics of practical significance not in M.E. 6424-5-6.

M.E. 6750. Systems Design Methodology

2-3-3. Prerequisite: graduate standing or consent of school.

Relationship of technological systems to society is studied using economic concepts. Emphasis on the use of engineering type analysis in resolving value laden problems. Examples. Cross-listed with A.E., E.E., C.E., C.P., I.Sy.E.

M.E. 6751-2. Complex Systems Design

2-4-3 each. Prerequisite: graduate standing in any school or senior with consent of school.

Interdisciplinary team design of systems of current interest to society which have large technological factors. Individual research and interaction with noninstitute resource persons and faculty. Grades based on oral and written reports. Cross-listed with A.E., E.E., C.E., C.P., I.Sy.E.

M.E. 6760-1. Acoustics I and II

3-0-3 each. Prerequisite: Math. 4349 or consent of school.

Governing equations of sound waves from the conservation laws. Acoustic momentum, energy and intensity. Propagation, reflection, absorption and scattering. Effects of the physical properties. Application of the theory of sound to real systems. Transmission of sound in real media.

M.E. 6762. Acoustics III

3-0-3. Prerequisite: M.E. 6761.

Advanced duct acoustics, wave dispersion and attenuation, acoustics in moving media, geometrical acoustics, nonlinear acoustics.

M.E. 6763. Noise Reduction and Control (Industrial Applications)

3-0-3. Prerequisite: M.E./A.E./E.S.M. 6760, M.E. 4023 or equivalent.

Methods of noise reduction and control applied to systems in industry. Measurement of sound power, material acoustic properties, barriers, enclosures, mufflers, vibration reduction and damping methods.

M.E. 6764. Ocean Acoustics

3-0-3. Prerequisite: Geo.S. 4300 or consent of school. Math. 4321, 4582, E.S.M. 6760 recommended.

Propagation of sound waves in the oceans, stress-strain relationships, asymptotic ray theory. Propagation in shallow water and deep water. Cross-listed with A.E., Geo.S., E.S.M.

M.E. 7000. Master's Thesis

M.E. 7010-1-2-3. Seminars in Mechanical Engineering

1-0-1. Prerequisite: graduate standing.

Seminars involving current research projects presented by graduate students, M.E. faculty and invited industrial speakers.

M.E. 7035. Numerical Methods in Mechanical Engineering

3-0-3. Prerequisite: graduate standing.

Numerical analysis of deterministic engineering systems. Numerical approximations to mathematical operations. Initial and boundary value problems. Computational stability for ordinary and linear partial differential equations.

M.E. 7122. Advanced Machine Vibrations

3-0-3. Prerequisite: M.E. 6122 or consent of school.

Applications of vibration theory. Machinery response on resilient mounting. Kinematic and dynamic stability. Nonlinear systems in electromechanical and mechanical design.

M.E. 7140. Decision Theory for Engineering Design

3-0-3. Prerequisite: Math. 4215 or consent of school.

Use of information-theory decision analysis in solving practice problems in engineering design and reliability which cannot be effectively treated by any other method.

M.E. 7220. High Temperature Deformation Processes

3-0-3. Prerequisite: M.E. 4265.

Mechanical properties of materials at elevated temperatures, creep behavior, deformation mechanisms, stress analysis. Design for temperature effects, thermal stress, notches, fracture, fatigue, corrosion and oxidation.

M.E. 7222-3. Fracture and Fatigue of Material I, II

3-0-3 each. Prerequisite: M.E. 6221.

Advanced study of failure of structural materials under load. Mechanics of fracture, microscopic and macroscopic aspects, fracture of specific materials; steels, nonferrous alloys, nonmetallic materials.

M.E. 7322. Thermodynamics of Irreversible Processes I

3-0-3. Prerequisite: graduate standing.

Principles and formalism of thermodynamics of near-equilibrium states. Phenomenological equations and the Onsager-Casimir reciprocal relations. Coupled linear processes and cross-effects.

M.E. 7323. Thermodynamics of Irreversible Processes II

3-0-3. Prerequisite: M.E. 7322 or equivalent.

Further study of the application of irreversible thermodynamics in linear processes. Variational formulation for nonequilibrium thermodynamics, current contributions towards the solution of non-linear problems.

M.E. 7336. Forced Convection Heat Exchange
3-0-3. Prerequisite: M.E. 6333.

Theory of forced convection heat exchange in recuperators, regenerators and devices with simultaneous heat and mass transfer, with emphasis on performance and thermal design.

M.E. 7338. Advanced Topics in Heat Transfer
3-0-3. Prerequisite: M.E. 6332, 6333, 6334.

Latest advances in heat transfer, boiling and two-phase flows, liquid metal heat transfer, influence of main stream turbulence, separated flows, porous media, radiation and conduction.

M.E. 7341. Transport Phenomena in Two Phase Flow I

3-0-3. Prerequisite: consent of school.

Dispersed and separated flows—field and constitutive equations, jump conditions. Interfacial phenomena, nucleation. Two-fluid and drift models, similarity, criteria. Dynamics, propagation phenomena, kinematic waves.

M.E. 7342. Transport Phenomena in Two-Phase Flow II

3-0-3. Prerequisite: consent of school.

Flow regimes, pressure drop, void fraction. Boiling forced convection vaporization. Atomization. Burn out and critical heat flux. Spray cooling. Condensation phase separation.

M.E. 8010-1-2-3. Seminars in Mechanical Engineering

1-0-1. Prerequisite: graduate standing.

Seminars involving current research projects presented by graduate students, M.E. faculty and invited industrial speakers.

M.E. 8039. Heat Transfer Seminar
1-0-1.

Two presentations by each student of current research activities; thesis work and special problems, presentation of thesis proposals. Attendance in curriculum-related seminars.

M.E. 8041-2-3-4-5. Fluid Mechanics Seminar
1, 2, 3, 4, 5 credit hours respectively. Prerequisite: consent of school.

Advanced current topic in fluid mechanics and fluid engineering including applications of interest to mechanical engineering.

M.E. 8101-2-3-4-5. Special Topics in Design

1, 2, 3, 4, 5 credit hours respectively. Prerequisite: consent of school.

Special topic offerings of current interest and not included in regular courses.

M.E. 8201-2-3-4-5. Special Topics in Materials

1, 2, 3, 4, 5 credit hours respectively. Prerequisite: consent of school.

Special topic offerings of current interest and not included in regular courses.

M.E. 8301-2-3-4-5. Special Topics in Energetics

1, 2, 3, 4, 5 credit hours respectively. Prerequisite: consent of school.

Special topic offerings of current interest and not included in regular courses.

M.E. 8401-2-3-4-5. Special Topics in Systems and Controls

1, 2, 3, 4, 5 credit hours respectively. Prerequisite: consent of school.

Special topic offerings of current interest and not included in regular courses.

M.E. 8501 through 8517. Special Problems in Mechanical Engineering

Credit to be arranged. Prerequisite: consent of school.

Individual studies in certain specialized areas and mathematical analyses and/or experimental investigations of problems of current interest in mechanical engineering.

M.E. 9000. Doctoral Thesis

METALLURGY

See Chemical Engineering.

MILITARY SCIENCE

M.S. 0110. Competitive Marksmanship

1-1-0.

Fundamental characteristics and firing techniques of the .22 caliber rifle for individual familiarization and participation in competitive events.

M.S. 0130. Ranger Company

1-1-0.

An organization designed to train and prepare the small unit leader with patrolling, military mountaineering and stream crossing operations in a demanding physical environment.

M.S. 1001. The Army of Today

2-1-1.

United States Army Missions and Organizations as related to national defense, land warfare and national objectives; the role of the army officer in today's dynamic environment.

M.S. 1002. Army Operational Systems

2-1-1.

The missions, employment and weapon systems of the United States Army general purpose forces. An examination of current and future operational systems.

M.S. 2001. Basic Military Leadership

2-1-1.

Develops essential fundamental military capabilities required of small unit leader, to include: communications and military intelligence, basic command control techniques and fundamental techniques of communications skills.

M.S. 2002. Analysis of Command and Leadership

2-1-1.

Group dynamics, individual motivation and analysis of leadership functions at the small unit level. Peer group relationships. Case studies on success and failure while in leadership positions.

M.S. 2003. Applications of Leadership

1-2-2.

Extensive use of group dynamics in a practical environment. Emphasis is placed on practical exercises requiring decision-making and leadership in a physically demanding environment.

M.S. 3001. Advanced Military Navigation

2-3-3.

The movement of military land forces at night and in periods of reduced visibility. Areas of emphasis: employing electronic navigation aids, celestial navigation and dead reckoning. Review of basic navigation with practical exercises in a field environment.

M.S. 3002. Tactical Decision-Making I

2-1-2.

Tactical decision-making at the small unit level. Emphasis is placed on practical experience in planning and executing tactical operations. The course is presented within a context requiring synthesizing of all prior Military Science courses.

M.S. 4001. The Military Team and the Junior Officer

2-1-2. Prerequisite: advanced ROTC standing.

A study of the broad principles, concepts and operations of the combined arms team and its supporting elements from other branches and

services. Emphasis is placed on the role of the junior officer in today's army.

M.S. 4002. Military Management Operations

2-1-2. Prerequisite: advanced ROTC standing.

Basic concepts and fundamentals of military administration, logistics and military justice.

M.S. 4003. Professional Ethics and the Army Officer

1-1-1.

The pressures and influences imposed by contemporary society on the military officer; the standards of conduct, integrity and special talent by which the military officers must function.

M.S. 4031. Military Engineering

2-1-2. Prerequisite: advanced ROTC standing.

Engineering operations as a part of the combat arms team. Emphasis is placed on engineer unit capabilities, techniques of offensive and defensive operations, military engineering management and command.

M.S. 4061. Tactical and Strategic Communications-Electronics Systems

2-1-2. Prerequisite: advanced ROTC standing.

Signal field communication systems engineering and control in subdivision level units. An analysis of division, corps and theater Army communications, including the U.S. Army Communications Command.

MODERN LANGUAGES

(Hum.) = Humanities credit

(Soc. Sci.) = Social Science credit

Students in the College of Engineering may include up to nine hours (twelve hours in Russian) of elementary foreign language study for *humanities* credit, provided nine additional hours are completed on the 2000 or higher levels; otherwise the 1000 level course will count as *elective* credit. This regulation does *not* apply to courses in linguistics.

F.L. 1001. Elementary Hebrew I

3-0-3. Prerequisite: none.

An intensive treatment of fundamentals of Hebrew—reading, writing, comprehension and speaking—utilizing an audio-lingual methodology and materials. (Hum.)

F.L. 1002. Elementary Hebrew II

3-0-3. Prerequisite: Hebrew 1001 or equivalent.

Continuation of Hebrew I. (Hum.)

F.L. 1003. Elementary Hebrew III

3-0-3. Prerequisite: Hebrew 1002 or equivalent.

Continuation of Hebrew II. (Hum.)

F.L. 1011. Elementary Portuguese I

3-0-3. Prerequisite: none.

The beginning course. Pronunciation, conversation, reading, composition, grammar. Audio-lingual methodology and materials. (Hum.)

F.L. 1012. Elementary Portuguese II

3-0-3. Prerequisite: F.L. 1011 or equivalent.

Continuation of M.L. 1011. (Hum.)

F.L. 1013. Elementary Portuguese III

3-0-3. Prerequisite: F.L. 1012 or equivalent.

Continuation of F.L. 1012. (Hum.)

F.L. 1021. Elementary Italian I

3-0-3. Prerequisite: None.

Introduction to Italian; pronunciation, grammar, conversation, composition and reading. (Hum.)

F.L. 1022. Elementary Italian II

3-0-3. Prerequisite: F.L. 1021 or equivalent.

Continuation of F.L. 1021. (Hum.)

F.L. 1023. Elementary Italian III.

3-0-3. Prerequisite: F.L. 1022 or equivalent.

Continuation of F.L. 1022. (Hum.)

F.L. 2011. Colonial Brazil and the Portuguese Empire, 1500-1808

3-0-3. Prerequisite: F.L. 1013 or equivalent.

Cultural history of Portuguese America from conquest and settlement to the end of the colonial period. Includes grammar review. Conducted in Portuguese. (Soc. Sci.)

F.L. 2012. Development of Independent Brazil, 1808-1930

3-0-3. Prerequisite: M.L. 1013 or equivalent.

Cultural history of Brazil from independence through the Empire and the Old Republic. Includes grammar review. Conducted in Portuguese. (Soc. Sci.)

F.L. 2013. Brazil since 1930; The Giant Emerges

3-0-3. Prerequisite: F.L. 1013 or equivalent.

Cultural history of contemporary Brazil from the rise of Vargas to the present day. Conducted in Portuguese. (Soc. Sci.)

F.L. 2021. Cultural History of Florence 1300-1500

3-0-3. Prerequisite: F.L. 1023 or equivalent.

Dante, Boccaccio and the Medici. Grammar review. Conducted in Italian. (Soc. Sci.)

F.L. 2022. Cultural History of Rome 1500-1700

3-0-3. Prerequisite: F.L. 1023 or equivalent.

Emphasis on Michelangelo, Bernini, Borromini. Grammar review. Conducted in Italian. (Soc. Sci.)

F.L. 2023. Cultural History of Italy since 1848

3-0-3. Prerequisite: F.L. 1023 or equivalent.

Unification, Fascism, resistance, post-war boom, current unrest. Conducted in Italian. (Soc. Sci.)

F.L. 3801-2-3-4. Special Topics in Modern Languages

3-0-3. Prerequisite: consent of head of department.

Permits students to do work in languages not treated in other courses and/or to engage in special research and/or experimental studies.

French**Fren. 1001. Elementary French I**

3-0-3. Prerequisite: none.

Essential principles of French grammar and phonetics, acquisition of vocabulary through simple conversational exercises and the reading of simple selections. (Hum.)

Fren. 1002. Elementary French II

3-0-3. Prerequisite: Fren. 1001 or equivalent.

Continuation of Fren. 1001, extension of the survey of French grammar, acquisition of a general vocabulary through conversation and reading. (Hum.)

Fren. 1003. Elementary French III

3-0-3. Prerequisite: Fren. 1002 or equivalent.

Reading of selected texts, composition, completion of the survey of French grammar. (Hum.)

Fren. 2001. Cultural History of France to 1610

3-0-3. Prerequisite: Fren. 1003 or equivalent or two years in high school.

Development and evolution of social structures of France as reflected in literature, history and art. Includes a review of grammar. Conducted in French. (Soc. Sci.)

Fren. 2002. Cultural History of France from 1610-1800

3-0-3. Prerequisite: Fren. 1003, 2 yrs. in high school or equivalent.

Development and evolution of social structures of France from 1610 to 1800, as reflected in literature, history and art. Continuation of a review of grammar. Conducted in French. (Soc. Sci.)

Fren. 2003. Cultural History of France since 1800

3-0-3. Prerequisite: Fren. 1003, 2 yrs. in high school or equivalent.

Development and evolution of social structures of France during the nineteenth and twentieth centuries as reflected in literature, history and

art. Concludes review of grammar. Conducted in French. (Soc. Sci.)

Fren. 2021-2-3. Intermediate Conversation I, II, III

1-3-2 each. Prerequisite: 1003, 2 yrs. in high school or equivalent.

A conversational approach to topics of current interest in the humanities in France. (Hum.)

Fren. 3001. French Literature from 1800-1850

3-0-3. Prerequisite: Fren. 2003 or equivalent.

Romanticism, the reappearance of lyric poetry, the importance of the individual as opposed to classical anonymity. Conducted in French. (Hum.)

Fren. 3002. French Literature from 1850-1900

3-0-3. Prerequisite: Fren. 2003 or equivalent.

Parnassianism and symbolism, developments in poetry, realism and naturalism, trends in prose, with emphasis on the development of the novel. Conducted in French. (Hum.)

Fren. 3003. French Literature since 1900

3-0-3. Prerequisite: Fren. 2003 or equivalent.

Exploration of currents in modern prose, poetry and drama. Conducted in French. (Hum.)

Fren. 3011. France Today I

3-0-3. Prerequisite: Fren. 2003 or equivalent

Culture, history and geography of modern France in lectures and class discussions, short papers on assigned topics; conducted in French. (Soc. Sci.)

Fren. 3012. France Today II

3-0-3. Prerequisite: Fren. 2003 or equivalent.

Continuation of Fren. 3011. (Soc. Sci.)

Fren. 3013. France Today III

3-0-3. Prerequisite: Fren. 2003 or equivalent.

Continuation of Fren. 3012. (Soc. Sci.)

Fren. 3021-2-3. Advanced Conversation I, II, III

1-3-2 each. Prerequisite: 2003, 2023, 3 yrs. in high school or equivalent.

A conversational approach to topics of current interest in the social sciences in France. (Soc. Sci.)

Fren. 4001. French Stylistics

3-0-3. Prerequisite: Fren. 3003 or equivalent.

Advanced study of syntax and semantics, aimed at development of stylistic sensitivity. Compositions in French. (Hum.)

Fren. 4002. Classical French Literature

3-0-3. Prerequisite: Fren. 3003 or equivalent.

Survey of French classical literature, readings in Malherbe, Descartes, Pascal, La Rochefou-

cauld, La Fontaine, La Bruyere, Corneille, Moliere and Racine. Lectures on the Classical Age; term report. Conducted in French. (Hum.)

Fren. 4003. The French Novel

3-0-3. Prerequisite: Fren. 3003 or equivalent.

Survey of the development of the French novel from the late seventeenth century through the twentieth century; term report. Conducted in French. (Hum.)

Fren. 4075. Intensive Readings in French I

3-0-3. Prerequisite: junior standing or consent of department.

Primarily for graduate students preparing for the Ph.D. reading knowledge examination. Emphasizes structures pertinent to reading comprehension particularly of scientific literature. Can also serve any students desiring a rapid review of basic French.

Fren. 4076. Intensive Readings in French II

3-0-3. Prerequisite: Fren. 4075.

Continuation of Fren. 4075.

Fren. 4077. Intensive Readings in French III

3-0-3. Prerequisite: Fren. 4076.

Continuation of Fren. 4076.

Fren. 4091-2-3. French Study Abroad

5-0-5 each. Prerequisite: junior standing.

The Study Abroad Program of the University System of Georgia. Fifteen quarter hours credit for summer study abroad. (4091, Hum.) (4092-3, Soc. Sci.)

Fren. 4901-2. Special Problems in French

Credit to be arranged.

Provides the special instruction required under special programs. (4901, Hum.) (4902, Soc. Sci.)

Fren. 7053. Contemporary French Media

4-3-5. Prerequisite: graduate standing.

Introduction to the significant French media and their usage in a classroom setting. Survey of teaching strategies, especially in relation to media. Conducted in French.

Fren. 7054. Advanced French Communicative Skills

4-3-5. Prerequisite: graduate standing.

For the improvement of teacher competency in the oral and written communicative skills. Intensive review and practice with native informants.

German**Ger. 1001. Elementary German I**

3-0-3. Prerequisite: None.

Pronunciation, essential principles of German

grammar, rapid acquisition of vocabulary by the reading of simple selections; elementary composition. (Hum.)

Ger. 1002. Elementary German II

3-0-3. Prerequisite: Ger. 1001 or equivalent.
Continuation of Ger. 1001. (Hum.)

Ger. 1003. Elementary German III

3-0-3. Prerequisite: Ger. 1002 or equivalent.
Reading and the acquisition of a large vocabulary; continued study of German grammar, composition. (Hum.)

Ger. 2001. Introduction to Modern German Culture I

3-0-3. Prerequisite: Ger. 1003 or equivalent.
Selected readings in German on the cultural, historical and intellectual development of Germany. Class discussion of reading material. (Soc. Sci.)

Ger. 2002. Introduction to Modern German Culture II

3-0-3. Prerequisite: Ger. 1003 or equivalent.
Continuation of Ger. 2001. (Soc. Sci.)

Ger. 2003. Introduction to Modern German Culture III

3-0-3. Prerequisite: Ger. 1003 or equivalent.
Continuation of Ger. 2002. (Soc. Sci.)

Ger. 2051. Issues in Science and Technology I

3-0-3. Prerequisite: Ger. 1003 or equivalent.
Reading, analysis and discussion of German texts dealing with past and present issues in the natural and social sciences. (Soc. Sci.)

Ger. 2052. Issues in Science and Technology II

3-0-3. Prerequisite: Ger. 2051 or equivalent.
Continuation of Ger. 2051 (Soc. Sci.)

Ger. 2053. Issues in Science and Technology III

3-0-3. Prerequisite: Ger. 2052 or equivalent.
Continuation of Ger. 2052; addition of individual projects to conform to the students special field of study. (Soc. Sci.)

Ger. 3001. Introduction to German Literature I

3-0-3. Prerequisite: Ger. 2003 or equivalent.
Literary masterpieces in German. Period: medieval times-1750. (Hum.)

Ger. 3002. Introduction to German Literature II

3-0-3. Prerequisite: Ger. 2003 or equivalent.
Literary masterpieces in German. Period: 1750-1840. (Hum.)

Ger. 3003. Introduction to German Literature III

3-0-3. Prerequisite: Ger. 2003 or equivalent.
Literary masterpieces in German. Period: 1840 to the present. (Hum.)

Ger. 3004. German Stylistics

3-0-3. Prerequisite: Ger. 2003 or equivalent.
Advanced study of syntax and semantics aimed at the development of stylistic sensitivity. Analysis of representative literary works for practice in composition and conversation. (Hum.)

Ger. 3011. Germany Today I

3-0-3. Prerequisite: Ger. 2003 or equivalent.
German lectures, papers and class discussions of German history, urban and rural morphology, post-war social and economic development in East and West Germany. (Soc. Sci.)

Ger. 3012. Germany Today II

3-0-3. Prerequisite: Ger. 2003 or equivalent.
Continuation of Ger. 3011; treatment of additional topics—German family life, educational system, church and religion, development of the arts, the Hitler era. (Soc. Sci.)

Ger. 3013. Germany Today III

3-0-3. Prerequisite: Ger. 2003 or equivalent.
Continuation of Ger. 3011 and 3012; in-depth treatment of contemporary issues. Supplementary instructional media: slides, recordings, journals and panel discussions. (Soc. Sci.)

Ger. 3031. The German Novelle I

3-0-3. Prerequisite: German 2003 or equivalent.
Period: 1795-1840. Goethe, Kleist, Tieck, Arnim, E.T.A. Hoffmann, Eichendorff. Conducted in German. (Hum.)

Ger. 3032. The German Novelle II

3-0-3. Prerequisite: German 2003 or equivalent.
Period: 1840-1885. Stifter, Keller, Storm, Ebner-Eschenback, Meyer. Conducted in German. (Hum.)

Ger. 3033. The German Novelle III

3-0-3. Prerequisite: German 2003 or equivalent.
Period: 1885 to the present. Hofmannsthal, Mann, Kafka, Musil, Wiechert, Borchert, Gaiser, Piontek. Conducted in German. (Hum.)

Ger. 3041. German Radio Drama I

3-0-3. Prerequisite: German 2003 or equivalent.
German radio drama as a literary genre. Study of works of representative dramatists. (Hum.)

Ger. 3042. German Radio Drama II

3-0-3. Prerequisite: German 2003 or equivalent.
An in-depth study of the works of Günter Eich. (Hum.)

Ger. 3043. German Radio Drama III

3-0-3. Prerequisite: German 2003 or equivalent.
Study of recorded radio dramas and preparation of a selected radio drama for presentation. (Hum.)

Ger. 3051. The German Folksong

3-0-3. Prerequisite: Ger. 2003 or equivalent.
Introduction to the wide range of human experience reflected in the German folksong. Emphasis on the appreciation of musical forms and literary aspects. (Hum.)

Ger. 4001. German Writers of the Twentieth Century I

3-0-3. Prerequisite: Ger. 2003 or equivalent.
Period: Naturalism—1920. Conducted in German. (Hum.)

Ger. 4002. German Writers of the Twentieth Century II

3-0-3. Prerequisite: Ger. 2003 or equivalent.
Period: 1920 to the present. Conducted in German. (Hum.)

Ger. 4003. Modern German Drama

3-0-3. Prerequisite: Ger. 2003 or equivalent.
A study of the leading German dramatists from the period of Naturalism to the present. Lectures, parallel readings, discussions. Conducted in German. (Hum.)

Ger. 4023. Selected Readings in German Literature

3-0-3. Prerequisite: Ger. 2003 or equivalent.
Study of selected authors, movements, genres and forms in German literature. Selections vary from year to year. Parallel readings, reports and papers. (Hum.)

Ger. 4075. Intensive Readings in German I

3-0-3. Prerequisite: junior standing or consent of department.

Primarily for graduate students preparing for the Ph.D. reading knowledge examination. Emphasizes structures pertinent to reading comprehension particularly of scientific literature. Can also serve any students desiring a rapid review of basic German.

Ger. 4076. Intensive Readings in German II

3-0-3. Prerequisite: Ger. 4075.
Continuation of Ger. 4075.

Ger. 4077. Intensive Readings in German III

3-0-3. Prerequisite: Ger. 4076.
Continuation of Ger. 4076.

Ger. 4091-2-3. German Study Abroad

5-0-5 each.
The Study Abroad Program of the University System of Georgia. Fifteen quarter hours credit

for summer study abroad. (4091, Hum.) (4092-3, Soc. Sci.)

Ger. 4901-2. Special Problems in German.
Credit to be arranged.

Provides the special instruction required under special programs. (4091, Hum.) (4902, Soc. Sci.)

Ger. 7053. Contemporary German Media

4-3-5. Prerequisite: graduate standing.
Significant German media and their usage in a classroom setting. Survey of teaching strategies, especially in relation to media. Conducted in German.

Ger. 7054. Advanced German Communicative Skills

4-3-5. Prerequisite: graduate standing.
For the improvement of teacher competency in the oral and written communicative skills. Intensive review and practice with native informants.

Hebrew

See F.L. 1001.

Italian

See F.L. 1021 and 2021.

Linguistics

The 1000-level courses are offered primarily for foreign students who wish to perfect their English.

Ling. 1001. Fundamentals of Phonology

3-0-3. Prerequisite: None.
English pronunciation contrasted with that of various foreign languages; vocabulary building; reading in linguistics. (Hum.)

Ling. 1002. Fundamentals of Morpho-syntax

3-0-3. Prerequisite: None.
Theoretical and practical approach to the study of English word and sentence formation using comparative data from different dialects and languages; grammar, punctuation, composition; readings in linguistics. (Hum.)

Ling. 1003. Fundamentals of Semantics, Stylistics and Socio-linguistics

3-0-3. Prerequisite: None.
A theoretical and practical approach to English semantic structure and stylistic levels; composition; readings in linguistics. (Hum.)

Ling. 2001. Introduction to Language I
3-0-3. Prerequisite: none.

Study of the design of natural language with emphasis on the traditional description of its phonological and grammatical systems. (Hum.)

Ling. 2002. Introduction to Language II
3-0-3. Prerequisite: Ling. 2001 or consent of department.

Introduction to modern grammatical and semantic theories of language. (Hum.)

Ling. 2003. Introduction to Language III.
3-0-3. Prerequisite: Ling. 2002 or consent of department.

Survey of the types of linguistic change and development, comparison of generic and genetic linguistic relationships, linguistic borrowing. (Hum.)

Ling. 3001. Introduction to Articulatory Phonetics
3-0-3. Prerequisite: Ling. 2003 or consent of department.

Introduction to articulatory and acoustic phonetics, methodology for analyzing sounds in various languages, with emphasis on recording sounds in phonetic script and reproduction of sounds. (Hum.)

Ling. 3002. Introduction to Structural Linguistics I
3-0-3. Prerequisite: Ling. 3001 or consent of department.

Methodology for phonological analysis of language, examination of phonological data from hypothetical and natural languages. Collateral readings, problems. (Hum.)

Ling. 3003. Introduction to Structural Linguistics II
3-0-3. Prerequisite: Ling. 3002 or consent of department.

Continuation of Ling. 3002 with emphasis on morphology and syntax, study of the works of Bloomfield, Pike and Harris. Collateral readings, problems. (Hum.)

Ling. 3004. Natural Language Processing
3-0-3. Prerequisite: None.

Primarily for I.C.S. students; study of selected topics from grammar and semantics which are important in the understanding and processing of natural language in human and computer contexts. (Hum.)

Ling. 4001. History of Linguistics
3-0-3. Prerequisite: prior study of linguistics or consent of department.

Survey of the theoretical developments in linguistic science with major emphasis on the de-

velopments of the nineteenth and early twentieth centuries. (Soc. Sci.)

Ling. 4002. Current Developments in Linguistics
3-0-3. Prerequisite: prior study of linguistics or consent of department.

Live issues in the field and approaches favored by various contemporary schools. (Hum.)

Ling. 4003. Semantics and Linguistic Structure

3-0-3. Prerequisite: prior study of linguistics or consent of department.

Various approaches to the problem of dealing with meaning in linguistic analysis. (Hum.)

Ling. 4021. Contrastive Language Systems
3-0-3. Prerequisite: Ling. 3001-2-3 or consent of department.

A comparison of the similarities and differences of selected major languages with English in respect to phonology, written representation, syntactic and semantic categories.

Ling. 4075-6-7. Comparative Analysis of Major European Languages I, II, III
3-0-3 each. Prerequisite: junior standing or consent of department.

Emphasis on grammatical and semantical structures and their correspondences. English as the control language. Ling. 4075 treats the major Slavic languages. Ling. 4076 treats the major Germanic languages. Ling. 4077 treats the major Romance languages.

Ling. 4901-2. Special Problems in Linguistics
Credit to be arranged.

Provides the special instruction required under special programs. (4901, Hum.) (4902, Soc. Sci.)

Portuguese

See F.L. 1011 and 2021.

Russian

Russ. 1001. Elementary Russian I
3-2-4. Prerequisite: none.

Pronunciation, essential principles of Russian grammar, acquisition of vocabulary through illustrative readings, intensive familiarization with recorded material. (Hum.)

Russ. 1002. Elementary Russian II
3-2-4. Prerequisite: Russ. 1001 or equivalent.
Continuation of Russ. 1001, introduction of ad-

ditional reading material as progress of class permits. (Hum.)

Russ. 1003. Elementary Russian III
3-2-4. Prerequisite: Russ. 1002 or equivalent
Continuation of Russ. 1002, emphasis on the reading of simple prose. (Hum.)

Russ. 2001. History and Culture of Russia I
3-0-3. Prerequisite: Russ. 1003 or equivalent.
Period: Ninth century to eighteenth. Review of grammar and oral practice. (Soc. Sci.)

Russ. 2002. History and Culture of Russia II
3-0-3. Prerequisite: Russ. 1003 or equivalent.
Period: Eighteenth century to 1917. Review of grammar and oral practice. (Soc. Sci.)

Russ. 2003. History and Culture of Russia III
3-0-3. Prerequisite: Russ. 1003 or equivalent.
Period: 1917 to the present. Review of grammar and oral practice. (Soc. Sci.)

Russ. 3001. Period: 1800-1860. Romanticism, The Golden Age of Russian Poetry, Naturalism
3-0-3. Prerequisite: Russ. 2003 or equivalent.
Readings in Russian. (Hum.)

Russ. 3002. Period: 1860-1900. The Golden Age of Russian Prose, Realism
3-0-3. Prerequisite: Russ. 2003 or equivalent.
Readings in Russian. (Hum.)

Russ. 3003. Period: 1900 to the Present. Symbolism, Futurism, Soviet Literature
3-0-3. Prerequisite: Russ. 2003 or equivalent.
Readings in Russian. (Hum.)

Russ. 4075. Intensive Readings in Russian I
3-0-3. Prerequisite: at least junior standing or consent of department.

Primarily for graduate students preparing for the Ph.D. reading knowledge examination. Emphasizes structures pertinent to reading comprehension particularly of scientific literature. Can also serve any students desiring a rapid review of basic Russian.

Russ. 4076. Intensive Readings in Russian II
3-0-3. Prerequisite: Russ. 4075.
Continuation of Russ. 4075.

Russ. 4077. Intensive Readings in Russian III
3-0-3. Prerequisite: Russ. 4076
Continuation of Russ. 4076.

Russ. 4901-2. Special Problems in Russian
Credit to be arranged.
Provides the special instruction required under special programs. (4901, Hum.) (4902, Soc. Sci.)

Spanish

Span. 1001. Elementary Spanish I
3-0-3. Prerequisite: none.

The beginning course. Pronunciation, grammar, reading, composition. Conversations with student assistants who are native speakers of Spanish. (Hum.)

Span. 1002. Elementary Spanish II
3-0-3. Prerequisite: Span. 1001 or equivalent.
Continuation of Span. 1001. (Hum.)

Span. 1003. Elementary Spanish III
3-0-3. Prerequisite: Span. 1002 or equivalent.
Continuation of Span. 1002. (Hum.)

Span. 2011. Discovery and Conquest of the New World, 1492-1600

3-0-3. Prerequisite: Span. 1003 or equivalent
The voyages of discovery and expeditions of conquest in sixteenth century Spanish America, with an introduction to the important Indian civilizations. Includes grammar review. Conducted in Spanish. (Soc. Sci.)

Span. 2012. Colonial Spanish America and the Wars of Independence, 1600-1900

3-0-3. Prerequisite: Span. 1003 or equivalent.
Spanish America from the period of the viceroyalties and Caribbean pirates to the Wars of Independence in the 1800s. Includes grammar review. Conducted in Spanish. (Soc. Sci.)

Span. 2013. Twentieth Century Spanish America

3-0-3. Prerequisite: Span. 1003 or equivalent.
Twentieth century Spanish America as a fusion of Spanish and native traditions, focusing on selected aspects of contemporary life in the Latin American countries. Conducted in Spanish. (Soc. Sci.)

Span. 3001. Spanish-American Literature Before 1895

3-0-3. Prerequisite: Span. 2013 or equivalent.
Conducted in Spanish. (Hum.)

Span. 3002. Spanish-American Literature Since 1895

3-0-3. Prerequisite: Span. 2013 or equivalent.
Conducted in Spanish. (Hum.)

Span. 3003. Introduction to Spanish Literature

3-0-3. Prerequisite: Span. 2013 or equivalent.
The cultural heritage of Spain in the Americas as reflected in representative European and Spanish-American literary works. Conducted in Spanish. (Hum.)

Span. 3004. Cultural History of Mexico

3-0-3. Prerequisite: Span. 2013 or equivalent.

Readings from representative authors. Vocabulary building, lectures, discussions, conversation and composition. (Soc. Sci.)

Span. 3005. Contemporary Latin America

3-0-3. Prerequisite: Span. 2013 or equivalent.

Selected contemporary essays, speeches and diverse documents reflecting social, economic and political problems. Conducted in Spanish. (Soc. Sci.)

Span. 3006. Stylistics

3-0-3. Prerequisite: Span. 2013 or equivalent.

Advanced study of syntax and semantics, aimed at development of stylistic sensitivity. Compositions in Spanish. (Hum.)

Span. 3007. Ancient and Medieval Spain

3-0-3. Prerequisite: Span. 2013 or equivalent.

History of Spanish civilization from prehistoric times to 1500. Conducted in Spanish. (Soc. Sci.)

Span. 3008. Hapsburg and Bourbon Spain

3-0-3. Prerequisite: Span. 2013 or equivalent.

History of Spanish civilization from Charles I to the Spanish American War of 1898. Conducted in Spanish. (Soc. Sci.)

Span. 3009. Spain Since 1898

3-0-3. Prerequisite: Span. 2013 or equivalent.

Contemporary essays, speeches and diverse documents reflecting social, economic and political problems of this century. Conducted in Spanish. (Soc. Sci.)

Span. 3011. The Short Story in Spain

3-0-3. Prerequisite: Span. 2013 or equivalent.

The short story in the literature of Spain from the Middle Ages to the twentieth century. Includes authors such as Cervantes, Valle-Inclan, Cela and Matute. (Hum.)

Span. 3012. The Latin American Short Story

3-0-3. Prerequisite: Span. 2013 or equivalent.

The short story in Latin America both as a literary genre and as an instrument of social revolution. Includes authors such as Echeverria, Dario, Lillo and Borges. (Soc. Sci.)

Span. 4007. Spanish Historical Linguistics

3-0-3. Prerequisite: Span. 3006 or equivalent.

Emphasis on phonology and morphology treated descriptively and comparatively. Brief survey of the historical development of the Spanish language. Conducted in Spanish. (Soc. Sci.)

Span. 4008. Libro de buen amor

3-0-3. Prerequisite: Span. 4007 or equivalent.

Detailed historical, linguistic and literary analysis of the Ruiz masterpiece as the vortex of

Spanish medieval civilization. Conducted in Spanish. (Soc. Sci.)

Span. 4009. Don Quijote, Part I

3-0-3. Prerequisite: Span. 3006 or equivalent.

Detailed historical study of Cervantes' masterpiece as the vortex of Spanish literature, the prototype of the modern novel and the essence of Renaissance and Baroque culture. Conducted in Spanish. (Soc. Sci.)

Span. 4010. Don Quijote, Part II

3-0-3. Prerequisite: Span. 3006 or equivalent.

Continuation of Span. 4009. (Soc. Sci.)

Span. 4021. Spanish Drama before 1700

3-0-3. Prerequisite: Span. 3006 or equivalent.

Emphasis on Lope de Vega and Calderon. Conducted in Spanish. (Hum.)

Span. 4022. Spanish Drama from 1700-1920

3-0-3. Prerequisite: Span. 3006 or equivalent.

Emphasis on Neo-classicism, Romanticism and the Generation of 1898. Conducted in Spanish. (Hum.)

Span. 4023. Spanish Drama since 1920

3-0-3. Prerequisite: Span. 3006 or equivalent.

Emphasis on Garcia Lorca and Casona. Conducted in Spanish. (Hum.)

Span. 4024. Spanish Prose before 1700

3-0-3. Prerequisite: Span. 3006 or equivalent.

Emphasis on the *Celestina*. Conducted in Spanish. (Hum.)

Span. 4025. Spanish Prose from 1700-1920

3-0-3. Prerequisite: Span. 3006 or equivalent.

Emphasis on precursors and members of Generation of 1898. Conducted in Spanish. (Hum.)

Span. 4026. Spanish Prose since 1920

3-0-3. Prerequisite: Span. 3006 or equivalent.

Emphasis on Spanish writers since the advent of the Franco regime. Conducted in Spanish. (Hum.)

Span. 4031. Latin American Novel I

3-0-3. Prerequisite: Span. 3003 or equivalent.

Emphasis on development of Latin American novel of social concern and its relation to the political and social climate. Detailed study of various 19th century and early 20th century masterpieces. Conducted in Spanish. (Hum.)

Span. 4032. Latin American Novel II

3-0-3. Prerequisite: Span. 3003 or equivalent.

The Latin American Novel since World War II. Emphasis on social and literary aspect of novels of the "boom" period. Represented are such au-

thors as Garcia Márquez, Vargas Llosa, Carpentier and Fuentes. Conducted in Spanish. (Hum.)

Span. 4075. Intensive Readings in Spanish I

3-0-3. Prerequisite: junior standing or consent of department.

Primarily for graduate students preparing for the Ph.D. reading knowledge examination. Emphasizes structures pertinent to reading comprehension particularly of scientific literature. Can also serve any students desiring a rapid review of basic Spanish.

Span. 4076. Intensive Readings in Spanish II

3-0-3. Prerequisite: Span. 4075.

Continuation of Span. 4075.

Span. 4077. Intensive Readings in Spanish III

3-0-3. Prerequisite: Span. 4076.

Continuation of Span. 4076.

Span. 4091-2-3. Spanish Study Abroad

5-0-5 each. Prerequisite: junior standing.

The Study Abroad Program of the University System of Georgia. Fifteen quarter hours credit for summer study abroad. (4091, Hum.) (4092-3, Soc. Sci.)

Span. 4901-2. Special Problems in Spanish

Credit to be arranged. Prerequisite: consent of department.

Provides the special instruction required under special programs. (4091, Hum.) (4092, Soc. Sci.)

Span. 7053. Contemporary Spanish Media

5-0-5. Prerequisite: graduate standing.

Significant Spanish media and their usage in a classroom setting. Survey of teaching strategies, especially in relation to media. Conducted in Spanish.

Span. 7054. Advanced Spanish Communicative Skills

4-3-5. Prerequisite: graduate standing.

For the improvement of teacher competency in the oral and written communicative skills. Intensive review and practice with native informants.

MUSIC

For a description of music courses, see p. 137. (Hum.) = Humanities credit.

Music 1101-2-3. Band

0-4-1. Prerequisite: consent of director. First course.

Music 1201-2-3. Chorale—Mixed Singing Group

0-4-1. Prerequisite: consent of director. First course.

Music 1301-2-3. Jazz Ensemble

0-4-1. Prerequisite: consent of director. First course.

Music 2101-2-3. Band

0-4-1. Prerequisite: consent of director. Second course.

Music 2201-2-3. Chorale—Mixed Singing Group

0-4-1. Prerequisite: consent of director. Second course. (Hum.)

Music 2301-2-3. Jazz Ensemble

0-4-1. Prerequisite: consent of director. Second course.

Music 3101-2-3. Band

0-4-1. Prerequisite: consent of director. Third course.

Music 3201-2-3. Chorale—Mixed Singing Group

0-4-1. Prerequisite: consent of director. Third course. (Hum.)

Music 3301-2-3. Jazz Ensemble

0-4-1. Prerequisite: consent of director. Third course.

Music 4101-2-3. Band

0-4-1. Prerequisite: consent of director. Fourth course.

Music 4201-2-3. Chorale—Mixed Singing Group

0-4-1. Prerequisite: consent of director. Fourth course.

Music 4301-2-3. Jazz Ensemble

0-4-1. Prerequisite: consent of director. Fourth course.

NAVAL SCIENCE

N.S. 1001. Naval Organization and Sea Power 2-1-2.

Introduction to structure and principles of naval organization, terminology, customs and uniforms, missions of the Navy as they relate to sea power and maritime affairs.

N.S. 1002. Naval Ship Systems I

2-1-2.

Discussion of naval ship design and construction. Examination of concepts and calculations of ship stability characteristics. Introduction to shipboard damage control.

N.S. 1003. Naval Ship Systems II

2-1-2. Prerequisite: N.S. 1002.

Shipboard propulsion, electrical and auxiliary

engineering systems are examined. Nuclear propulsion, gas turbines and other developments in naval engineering are presented.

N.S. 2012. Seapower and Maritime Affairs
2-1-2.

The broad principles, concepts and elements of the topic with historic and modern applications to the United States and other nations.

N.S. 2013. Naval Weapons Systems I
2-1-2.

A fundamental working knowledge of weapon system components and their contribution to the overall system is provided. The relationships of systems and subsystems are explored.

N.S. 2014. Naval Weapons Systems II
2-1-2. Prerequisite: N.S. 2013.

Employment and utilization of naval weapons systems are studied. An understanding of the capabilities of weapons systems and their role in the Navy's strategic mission.

N.S. 3001. Navigation I
3-2-3.

Theory and technique of navigation at sea. Areas of emphasis: dead reckoning, piloting, rules governing waterborne traffic. Practical applications utilizing nautical charts, tables and instruments.

N.S. 3002. Navigation II

3-2-3. Prerequisite: N.S. 3001 or consent of department.

Determination of position at sea using the marine sextant to observe heavenly bodies, principles/applications. Utilization of advanced electronic navigation systems is also introduced.

N.S. 3003. Naval Operations

3-2-3. Prerequisite: N.S. 3002 or consent of department.

Elements and principles of naval operations. Command responsibility, tactical doctrine, communication procedures and relative movement problems introduced. Practical applications include review of basic navigation techniques.

N.S. 4011. Naval Leadership and Management I
3-1-3.

Survey of the development of managerial thought through functional, behavioral and situational approaches. Managerial functions, communication, and major theories of leaders and motivation applied to the Navy organization. Accountability of the naval officer for the performance of both subordinates and technical systems is emphasized.

N.S. 4012. Naval Leadership and Management II
2-1-2.

Discussion of the administrative duties and responsibilities of the junior naval officer for personnel management and division discipline. Includes study of significant features of Navy Regulations and Military Law and detail in the areas of enlisted performance evaluation, advancement and service records.

N.S. 4013. Naval Leadership and Management III
2-1-2.

Introduction to the Navy Human Resources Management Support System. The junior naval officer's duties and responsibilities for material maintenance and personnel training. Seminars in elements of personal affairs planning including finance, orders, benefits, travel and related topics.

N.S. 4901-2-3. Special Problems in Naval Science

Credit to be arranged. Prerequisite: submission of a 500-word statement detailing the expected area of study to the professor of naval science and permission from the professor of naval science to enroll.

Selected students pursue creative research in specialized areas of naval science under the supervision of a staff officer whose career specialty is in that field. Professional papers of publishable quality and depth will be sought. Students have the option of studying for one, two or three credit hours per quarter and for one, two or three quarters of the academic year.

Marine Corps Option

N.S. 3004. Naval Science Laboratory
0-2-0.

Marine Corps leadership laboratory. Grade of S given for satisfactory completion. Taken by all junior Marine option midshipmen during spring quarter.

N.S. 3005-6. Evolution of Warfare I and II
3-2-3 each.

Two-quarter sequence explores forms of warfare practiced by great peoples in history. Selected campaigns are studied, emphasis on impact of leadership, evolution of tactics, weaponry, principles of war.

N.S. 4004-5. Amphibious Warfare I and II
3-2-3 each.

Two-quarter sequence designed to study projection of seapower ashore, emphasis on evolu-

tion of amphibious warfare in 20th century. Strategic concepts, current doctrine discussed.

N.S. 4006. Naval Science Laboratory
0-2-0.

Marine Corps leadership laboratory to prepare senior Marine option for commissioning. Grade of S given for satisfactory completion.

NUCLEAR ENGINEERING

Nuclear Engineering

N.E. 1100. Energy and Engineers in Society
2-3-3.

Deals with the concept of energy, society's requirements, the sources of supply, power generation methods and related environmental influences.

N.E. 3110. Nuclear Radiation Detection
2-6-4. Prerequisite: Phys. 3001.

A laboratory introduction to the principles and characteristics of basic detectors for nuclear radiations and the electronic systems associated with them.

N.E. 3211. Elements of Nuclear Engineering
3-0-3. Prerequisite: Phys. 2123; corequisite: Math. 2309.

An introduction to the field of nuclear engineering. Topics include neutron interactions in matter, the classification of fission chain reactors, nuclear fuels and neutron diffusion theory.

N.E. 4001-2-3. Nuclear Engineering Seminar
1-0-0 each.

A regularly scheduled, noncredit course required of all N.E. seniors. Various topics presented by guest speakers, faculty members and graduate students.

N.E. 4115. Nuclear Engineering Calculations with Digital Computers I
2-0-1.

Introduction to computer programming with emphasis on solution of problems relevant to nuclear engineering.

N.E. 4201. Nuclear Reactor Physics I
3-0-3. Prerequisite: Phys. 3001, N.E. 3211; Corequisite: Math. 4582.

The course covers the physical principles of nuclear reactors. Major topics include the diffusion equation, neutron moderation, neutron thermalization and criticality conditions.

N.E. 4202. Nuclear Reactor Physics II
3-0-3. Prerequisite: N.E. 4201.

Topics include the multigroup diffusion

method, heterogeneity effects, reactor kinetics and reactivity changes.

N.E. 4205. Reactor Laboratory
1-6-3. Prerequisite: N.E. 4202

Reactor principles and operational parameters. Approach to criticality, measurements of control rod worth, power distribution, void and temperature coefficients, importance function, absolute flux and the thermal spectrum.

N.E. 4210. Reactor Operations
1-6-3. Prerequisite: senior standing and consent of school.

Provides experience in all phases of reactor operation.

N.E. 4211. Reactor Engineering I
3-0-3. Prerequisite: M.E. 3720, Ch.E. 3301 or equivalent.

Current and proposed nuclear reactor power plants. Thermodynamic and fluid flow aspects of reactor system design. Heat generation and conduction in nuclear reactor systems.

N.E. 4212. Reactor Engineering II
3-0-3. Prerequisite: N.E. 4211, I.Sy.E. 4725 or equivalent.

Single- and two-phase heat convection in nuclear power plants. Analysis of load and thermal stresses in nuclear power plant components. Nuclear power plant fuel cycle and economics.

N.E. 4230. Nuclear Engineering Design
2-6-4. Prerequisite: N.E. 4212, 4202.

A complete design project of a nuclear power station. Nuclear computer codes will be used to aid in the design.

N.E. 4260. Radiation Transport and Shielding
3-0-3. Corequisite: N.E. 4202 or equivalent.

Transport theory as applied to radiation transport in homogeneous and heterogeneous bulk media. Emphasis on neutron and gamma-ray transport, both theoretical and applied.

N.E. 4261. Boiling Water Reactor Systems and Operations

3-0-3. Prerequisite: N.E. 4701 and 4201 or consent of school.

An analysis of operating characteristics of boiling water reactors.

N.E. 4301. Nuclear Fuel Cycle

3-0-3. Prerequisite: senior standing in nuclear engineering or consent of school

Systematic review of technologies used at fuel cycle facilities (other than reactors). Introduces economic, energy, environmental, safety and licensing aspects.

N.E. 4610. Introduction to Fusion Power

3-0-3. Prerequisite: senior standing in science or engineering.

An introduction to the concepts of fusion power. Basic plasma physics and technology of magnetic confinement fusion devices. Current reactor designs are discussed.

N.E. 4620. Nuclear Technology and the Environment

3-0-3. Prerequisite: senior standing in science or engineering or consent of school.

Survey of technical and social aspects of nuclear technology that relate to the natural environment and to national energy policies.

N.E. 4630. Isotopic Tracer Methodology

2-3-3. Prerequisite: senior standing in science or engineering or consent of school.

Introduction to isotopic tracer techniques for scientific and industrial applications in the biological, physical, medical or environmental sciences.

N.E. 4701. Nuclear Reactor Engineering I

3-0-3. Prerequisite: Math 2309.

N.E. 4701-2-3 are designed to provide a comprehensive sequence in nuclear reactor engineering. Topics include nuclear reactions, interaction of radiation with matter and diffusion of neutrons.

N.E. 4702. Nuclear Reactor Engineering II

3-0-3. Prerequisite: N.E. 4701.

Steady state reactor theory, use of multigroup neutron diffusion theory computer codes, reactor kinetics, effects of fission product poisoning, field trips to nuclear installations.

N.E. 4703. Nuclear Reactor Engineering III

3-0-3. Prerequisite: N.E. 4702.

Reactor control, reactor operation, energy removal, reactor design, reactor system descriptions, field trips.

N.E. 4780. Energy Conversion Engineering

3-0-3. Prerequisite: M.E. 3720 or equivalent.

Energy sources, demand and supply; large electric generating systems (fossil, hydro, nuclear), energy storage, advanced generating systems (solar, geothermal, fusion), direct energy conversion (thermoelectric, thermionic, MHD, fuel-cells).

N.E. 4801-2-3. Special Topics

3-0-3. Prerequisite: consent of school.

The purpose of this course is to permit the School of Nuclear Engineering to offer formal courses on topics of special interest on an ad hoc basis.

N.E. 4901-2-3-4. Special Problems

Credit to be arranged. Prerequisite: consent of school.

Special engineering problems will be assigned to the student according to his or her needs and capabilities to foster individual effort and experience in research techniques.

N.E. 6101. Introduction to Nuclear Materials

3-0-3.

Introduction to the nuclear fuel cycle, raw materials, extraction, enrichment, fabrication, reprocessing. Metallurgy of uranium, ceramic fuels, cladding and control materials and coolants.

N.E. 6102. Nuclear Fuel Elements

3-0-3. Prerequisite: N.E. 6101 or consent of school.

Reactor fuel technology, including fuel preparation, assembly and testing. In-core performance of fuel elements and fuel design procedures.

N.E. 6103. Nuclear Reactor Analysis I

3-0-3. Prerequisite: graduate standing or consent of school.

Covers nuclear reactor physics at the graduate level. Major topics include neutron thermalization, diffusion theory and energy group constants.

Text: at the level of Henry, *Nuclear Reactor Analysis*.

N.E. 6104. Nuclear Reactor Analysis II

3-0-3. Prerequisite: N.E. 6103.

Topics include reactivity variation with life-time, reactor kinetics, neutron transport theory and derivation of diffusion theory from transport theory.

Text: at the level of Henry, *Nuclear Reactor Analysis*.

N.E. 6110. Radiation Detection I

2-6-4. Prerequisite: Phys. 6011 or equivalent.

Principles of radiation detection systems in common use. Included are interaction mechanisms, detector response, design and selection criteria for detectors and indicating circuits.

N.E. 6111. Advanced Radiation Detection

3-0-3. Prerequisite: N.E. 6110 or equivalent.

Selected topics on modern radiation detection methods and fast pulse-circuit systems. Emphasis on neutron detection methods, scintillation detectors and semiconductor devices.

N.E. 6113. Radiation Effects on Materials

3-0-3. Prerequisite: N.E. 6101 or equivalent.

Review of major effects of radiation damage and related structural changes in solids. Semiconductors, organic materials and reactor components are covered.

N.E. 6125. Nuclear Engineering Calculations with Digital Computers II

3-0-3. Prerequisite: N.E. 4115 or equivalent.

Reviews numerical analysis with application to problems of nuclear reactors and associated nuclear physics and engineering. Programs are written and run in FORTRAN.

N.E. 6126. Monte Carlo Methods in Nuclear Engineering.

3-0-3. Prerequisite: consent of school.

Introductory course with application to radiation transport. Statistical background, generation and testing of pseudorandom numbers, random variables, applications to shielding and reactor physics, variance reduction methods.

N.E. 6140. Advanced Nuclear Fuel Cycle

3-0-3. Prerequisite: consent of school.

Survey of the nuclear fuel cycle. Technologies of raw materials production, uranium conversion and enriching, fuel fabrication and reprocessing, waste management, economic and safety analyses.

N.E. 6201. Advanced Nuclear Reactor Physics I

3-0-3. Prerequisite: N.E. 6104.

The course covers the neutron transport equation and its solution by spherical harmonics, Fourier transforms and discrete ordinates methods. Multigroup methods are also covered.

N.E. 6202. Advanced Nuclear Reactor Physics II

3-0-3. Prerequisite: N.E. 6201.

A continuation of N.E. 6201. Topics include: adjoint equation, perturbation theory, variational methods, neutron thermalization, resonance, absorption and reactor dynamics.

N.E. 6205. Nuclear Engineering Laboratory

1-6-3. Prerequisite: N.E. 6104.

Sequence of experiments elucidating reactor physics principles. Nuclear reactors, subcritical assembly, pulsed neutron generators and isotopic neutron sources are used.

N.E. 6211. Nuclear Reactor Technology I

3-0-3. Prerequisite: M.E. 3720 or equivalent.

Current and proposed nuclear reactor power plants. Thermodynamic and fluid flow aspects of reactor system design. Heat generation and conduction in nuclear reactor systems.

N.E. 6212. Nuclear Reactor Technology II

3-0-3. Prerequisite: N.E. 6211 or 4211.

Single- and two-phase heat convection in nuclear power plants. Analysis of load and thermal stresses in nuclear power plant components. Nuclear power plant fuel cycle and economics.

N.E. 6220. Advanced Engineering Design

2-6-4. Prerequisite: N.E. 4202 and 4212 or 6212.

Course intended to give experience in the synthesis of principles of nuclear engineering in the design of nuclear reactors and other facilities.

N.E. 6229. Applied Reactor Theory

3-0-3. Prerequisite: N.E. 4202 or 6104.

The course covers the physical principles employed in computer codes used in the design of fast and thermal reactors. The codes will be used by the students to calculate design parameters.

N.E. 6230. Reactor Kinetics and Control

3-0-3. Prerequisite: N.E. 4202 or equivalent.

This course includes equations describing reactor time-dependent behavior, elementary control theory, feedback effects and stability analysis.

6232. Nuclear Fuel Management

3-0-3. Prerequisite: N.E. 6251, 6760 or equivalent.

Nuclear fuel procurement options will be examined with regard to financing, scheduling, guarantees, risk and cost. Computational emphasis will be on in-core fuel management.

N.E. 6235. Nuclear Reactor Safety

3-0-3. Prerequisite: consent of school.

Licensing procedures, sources of potential hazard, accident transients, engineered safeguards, incipient failure, diagnostic techniques and safety analysis reports are discussed.

N.E. 6237. Fast Reactor Physics and Technology

3-0-3. Prerequisite: N.E. 6104.

The course covers reactor physics and design topics of importance for fast breeder reactors.

N.E. 6251. Fundamentals of Nuclear Engineering

3-0-3. Prerequisite: Phys. 6011.

Reactor principles, operation, materials, control and use.

N.E. 6260. Radiation Attenuation

3-3-4. Prerequisite: N.E. 6104.

Interaction of radiation with matter in bulk, absorption, scattering and attenuation of nuclear radiation, radiation transport theory, geometrical considerations and transport solution methods.

N.E. 6601. Radioisotopes Engineering I

3-0-3. Prerequisite: Phys. 6011 or equivalent.

Production and handling of radioisotope sources. Industrial applications of tracer methods and radiation sources. Design procedures for radiation gauges and high-level irradiation facilities.

N.E. 6602. Radioisotopes Engineering II
3-0-3. Prerequisite: N.E. 6601.

Production and economics of large-scale radiation sources for process systems and power sources. Analysis and design of practical systems and case studies.

N.E. 6623. Fusion Plasma Analysis I
3-0-3. Prerequisite: N.E. 4610 or equivalent.

Fundamental fusion plasma properties, motion of charged particles in magnetic fields, fluid description of plasmas and transport processes in magnetically confined plasmas.

N.E. 6624. Fusion Plasma Analysis II
3-0-3. Prerequisite: N.E. 6623.

Plasma equilibrium and stability, waves in plasmas, plasma heating and fueling, radiative processes, plasma-wall interaction, plasma dynamics, fusion reactor plasma parameters.

N.E. 6625. Fusion Reactor Technology
3-0-3. Prerequisite: N.E. 6624 and N.E. 6632

Technology and physics aspects of fusion reactor plant analysis and design, superconducting magnets, neutral beams, vacuum systems, confinement concepts, economics analysis and optimization.

N.E. 6626. Plasma Equilibrium and Transport
3-0-3. Prerequisite: N.E. 6624

Advanced treatment of plasma equilibria with flows, fluid and kinetic theories of plasma transport, and the evolution of flux surface configurations.

N.E. 6631. Fusion Nuclear Engineering I
3-0-3. Prerequisite: N.E. 4610, N.E. 6615, N.E. 6103 or equivalent.

Neutronics and photonics analysis and design of the blanket and shield for fusion reactors, tritium breeding, nuclear heating, response functions, induced activation, radiation transport and protection.

N.E. 6632. Fusion Nuclear Engineering II
3-0-3. Pre/Corequisite: N.E. 6631, Met. 4403 or M.E. 3212, N.E. 4714 or equivalent.

Materials and thermal-hydraulics analysis and design of the first wall and blanket for fusion reactors, radiation damage and radiation effects, heat transfer and transport.

N.E. 6680. Advanced Energy Conversion I
3-0-3.

Topics include energy sources, dynamic systems, thermoelectric conversion, fuel cells, solar power, MHD and the design of practical and useful power systems.

N.E. 6681. Advanced Energy Conversion II
3-0-3. Prerequisite: N.E. 6680.

Explores the topics covered in N.E. 6680 in greater depth. Current programs aimed at developing advanced power sources are discussed.

N.E. 6760. Financial Management and Economics of Nuclear Power
3-0-3. Prerequisite: consent of school.

Topics include nuclear reactor and fuel cycle, electrical power systems and utility economics, financial management and system modeling. Identical to Econ. 6760.

N.E. 6770. Small Computer Interface Engineering and Applications
2-6-4.

The use of computers in data acquisition and control digital logic, interfacing, computer structures and the hardware-software trade-off are covered. First course in computer engineering options.

N.E. 6771. Engineering Computer Software Systems.
3-3-4. Prerequisite: N.E. 6770.

Computer programming for real-time process control systems in complex multiple-task device-oriented environments. Subjects include assembler programming, operating systems and real-time systems on minicomputers.

N.E. 6772. Advanced Computer Interfacing and Digital Design
2-3-3. Prerequisite: N.E. 6770.

A study of system design using MSI and LSI chips and programmable digital devices as system modules. Subjects include Boolean optimization and register transfer design techniques.

N.E. 6773. Computer Control of Real-time Systems.
3-3-4. Prerequisite: N.E. 6770, E.E. 4077 or equivalent.

A study of concepts common to all computer controlled real-time systems. Subjects include evolution of time sets, vectored interrupts and statistical alarm conditions.

N.E. 6775. Advanced Engineering Programming Methods
3-3-4. Prerequisite: FORTRAN programming knowledge.

Advanced engineering programming concepts and their implementation on large scale digital computers. Dynamic data, dynamic programs, engineering data management, primary memory management, engineering problem-oriented language development and ICES.

N.E. 7000. Master's Thesis

N.E.7999. Preparation for Doctoral Qualifying Examination
Noncredit. Prerequisite: consent of school.

N.E. 8001-2-3. Seminar
1-0-0 each.

Regularly scheduled, noncredit course required of all N.E. majors. Various topics presented by guest speakers, faculty members and graduate students.

N.E. 8110-1-2-3. Special Topics
3-0-3. Prerequisite: consent of school.

Purpose of this course is to permit the School of Nuclear Engineering to offer formal courses on topics of special interest on an ad hoc basis.

N.E. 8501-2-3-4. Special Problems
Credit to be arranged. Prerequisite: consent of school.

The student is encouraged to exercise resourcefulness and originality in attacking a problem of special interest to himself or herself and a member of the N.E. faculty.

N.E. 8999. Doctoral Dissertation Preparation

N.E. 9000. Doctoral Dissertation.

Health Physics

H.P. 2401-2-3. Introduction to Health Physics
1-0-1 each. Prerequisite: sophomore standing.

A course designed to familiarize the student with the health physics profession and the role of the health physicist in industry, medicine and public health.

H.P. 4401-2-3. Health Physics Seminar
1-0-1 each. Prerequisite: consent of school.

Intended primarily for students who plan a career in health physics. Review of current literature and current activities in the profession with class discussions.

H.P. 4411. Radiation Physics
3-3-4. Prerequisite: Math. 2309, Phys. 2123.

This course provides the physical basis for understanding the effects of ionizing radiation on matter, for developing a philosophy of radiation protection for individuals and the environment.

H.P. 4412. Principles of Health Physics
3-0-3. Prerequisite: Phys. 3001 or H.P. 4411.

Course emphasizes the biophysical basis of radiation protection and the development of protection criteria.

H.P. 4413. Applied Health Physics
3-3-4. Prerequisite: H.P. 4412 or consent of school.

Topics covered include personnel monitoring,

bioassay, air sampling and respiratory protection, radiation surveys of nuclear reactors, accelerators and X-ray installations.

H.P. 4440. Effect of Nonionizing Radiation and Protection Standards
3-0-3. Prerequisite: consent of school and H.P. 4412 or equivalent.

A study of methods of production and control of exposure to nonionizing radiations and a review of effects of human exposure and of the radiation protection standards

H.P. 6401. Radiological Health Physics
3-0-3. Prerequisite: consent of school. Corequisite: Phys. 6011 or equivalent.

An evaluation of radiation protection standards, their development and enforcement. Covers topics such as effects of radiation, internal and external exposure, health physics practice and dosimetry.

H.P. 6405. Health Physics Practice
3-0-3. Prerequisite: H.P. 4413 or 6401 or equivalent.

A review of many types of radiation problems—both basic and applied—relating to the qualifications of a certified health physicist.

H.P. 6410. Radiation Dosimetry
3-0-3. Prerequisite: H.P. 6401 and N.E. 6110, or consent of school.

Fundamental principles of dosimetry of ionizing radiations. Includes Bragg-Gray theory, absorbed and integral dose, influence of field size and dosimetry of internal emitters.

H.P. 6411. Applied Radiation Physics
2-3-3. Prerequisite: H.P. 6410 or consent of school.

Standardization of radiation sources, measurement of absorbed dose and interaction of ionizing radiation with scattering medium.

H.P. 6412. Radiation Dosimetry Systems
1-6-3. Prerequisite: H.P. 6411 or consent of school.

Deals with calibration of ionizing radiation sources and the evaluation of the dose distribution produced by them, or mixtures of them, in biological materials.

H.P. 6413. Radiation Technology Laboratory
1-6-3. Prerequisite: N.E. 6110.

Advanced laboratory course covering various aspects of radioisotope applications, tracer technology, radiation chemistry and activation analysis as applied in health physics.

H.P. 6429. Particle Accelerators
2-3-3. Prerequisite: Phys. 6011 or consent of school.

Principles of particle accelerators including acceleration methods, ion sources and targets, characteristics of machines such as electrostatic generators, betatrons, linear accelerators, cyclotrons, synchrotrons and synchrocyclotrons. Design and operation of X-ray and neutron generators covered in laboratory.

H.P. 6430. Radiation Protection in Nuclear Facilities

1-6-3. Prerequisite: H.P. 6405 or 4413 and N.E. 4710 or equivalent.

Review of radiation protection requirements at nuclear facilities, radiation monitoring, environmental surveillance planning and procedures for sample analyses and waste management.

H.P. 6442. Applied Health Physics Laboratory

1-6-3. Prerequisite: H.P. 6430.
A laboratory course covering practical aspects of monitoring problems in nuclear facilities and environmental surveillance analyses.

H.P. 6641. Environmental Surveillance and Radioactive Waste Disposal

3-0-3. Prerequisite: consent of school.

Advanced course on environmental radioactivity and environmental aspects of nuclear power. Radioactive waste treatment, reactor effluents and waste disposal. Identical to H.P. 6783 but without the laboratory.

H.P. 6643. Environmental Impact of Nuclear Power Stations

3-0-3. Prerequisite: H.P. 6641 or consent of school.

Specific impact of nuclear facilities on the environment. Practical and regulatory aspects of reactor siting and the preparation of environmental impact statements.

H.P. 6783. Environmental Surveillance and Radioactive Waste Disposal

3-3-4. Prerequisite: C.E. 6133, H.P. 6401 or consent of school.

Advanced course on environmental radioactivity and environmental aspects of nuclear power. Radioactive waste treatment, reactor effluents and waste disposal. Lecture portion of this course is identical to H.P. 6641.

H.P. 7000. Master's Thesis

H.P. 7999. Preparation for Doctoral Qualifying Examination

Noncredit. Prerequisite: consent of school.

H.P. 8999. Doctoral Dissertation Preparation

H.P. 9000. Doctoral Dissertation.

PHILOSOPHY AND HISTORY OF SCIENCE

See Social Sciences.

PHYSICAL EDUCATION AND RECREATION

Unless medically disqualified, all students will be required to complete swimming (P.E. 1010) plus two additional courses. One of these must be selected from the remaining courses at the 1000 level and one must be selected from the 2000 level.

P.E. 1010. Swimming

0-4-1.

Each student strives for maximum safety by thoughtful experimentation with simulated water emergencies. Drownproofing evolves as the basic method for survival.

P.E. 1020. Physical Fitness and Gymnastics

0-4-1.

Gymnastic movement is the medium through which students develop and learn to maintain essential elements of fitness including flexibility, coordination, strength, balance and kinesthetic awareness.

P.E. 1030. Women's Gymnastics

0-4-1.

Instruction, demonstration and practice of basic women's gymnastics skills utilizing the four Olympic women's events. Flexibility and general physical conditioning exercises will be included.

P.E. 1040. Health Education

3-0-3.

Guest lecturers from the medical and allied health profession acquaint the student with contemporary personal health concerns including drugs, nutrition, emotional health and sex education.

P.E. 1050. Aerobic Conditioning

0-4-1.

Primary emphasis is placed on the improvement of endurance and of cardiovascular and respiratory system efficiency through an individually tailored program of jogging and recreational sports.

P.E. 1060. Fitness: Theory, Evaluation and Conditioning

2-2-2.

Basic concepts on which lifetime fitness programs are founded. Role of exercise in health, weight control and quality of life. Assessment of personal fitness and individualized exercise program for each student. Combination of lectures, laboratory demonstrations and conditioning activities.

P.E. 1090. Physical Conditioning

0-4-1.

Instruction, demonstration and practice of basic physical conditioning with emphasis on muscular strength. Activities include running, stretching, calisthenics, weight and circuit training.

P.E. 2010. Archery

0-4-1.

Instruction in basic fundamental skills such as proper stance, grip of bow sight, release and follow through.

P.E. 2020. Intermediate and Advanced Gymnastics

0-4-1. Prerequisite: P.E. 1020 or 1030 or prior gymnastics experience.

The primary goal will be to develop a sufficient diversity of gymnastic skills beyond the beginning levels so that one may participate on a recreational basis or as an adjunct to a physical fitness program. Instruction in skills in the ten international competitive events for men and women and acrobatics will be included.

P.E. 2040 Softball

0-4-1

Demonstration and practice of basic fundamentals followed by organized competition.

P.E. 2050. Beginning Tennis

0-4-1.

Designed for the beginning player. Introduction to fundamentals; ground strokes, basic serve and volley. Rules and etiquette included.

P.E. 2051. Intermediate Tennis

0-4-1.

Concentration on intermediate skills; stroke refinement, spins, singles and doubles strategy.

P.E. 2055. Badminton

0-4-1.

Demonstration and practice of fundamentals including grip, playing positions, footwork, strokes and application of basic techniques and strategy to actual playing situations in singles and doubles.

P.E. 2060. Volleyball

0-4-1.

The serve, spiking, passing, team defensive and offensive play will be demonstrated and practiced after which team competition is organized.

P.E. 2070. Racquetball

0-4-1.

Scoring, defensive and offensive strategy along with basic fundamentals of the serve and volley will be demonstrated and practiced. Singles and doubles competition will be organized.

P.E. 2080. Bowling

0-4-1.

Team and league bowling competition follows an instructional program utilizing both live and filmed demonstration of basic skills and techniques.

P.E. 2090. Advanced Physical Conditioning

0-4-1. Prerequisite: P.E. 1090 or consent of the instructor.

Instruction and practice of advanced physical conditioning with emphasis on developing an individualized strength training program. Primary activities include calisthenics, weight and circuit training.

P.E. 2100. Fencing

0-4-1.

Demonstration and practice of fencing fundamentals and rules with the French foil as the weapon. Practice bouting and officiating will follow partial mastery of these skills.

P.E. 2101. Intermediate and Advanced Fencing

0-4-1. Prerequisite: P.E. 2100, or consent of the department.

Review and mastery of the fencing fundamentals, plus instruction in advanced and competitive techniques.

P.E. 2110. Basketball

0-4-1.

The basic fundamentals of the game will be practiced. Team competition will then be organized.

P.E. 2130. Soccer

0-4-1.

Organization of teams and competition follows skills practice and demonstration of offensive and defensive strategy. Position assignments, safety and game rules discussed.

P.E. 2140. Athletic Officiating
2-2-1.

Study of rules with laboratory experience. Instruction, demonstration and practical application of mechanics of officiating athletic games. Will help meet entrance requirements for professional officiating.

P.E. 2150. Advanced Lifesaving
0-4-1.

Instruction, demonstration and practice of carries, approaches and releases utilized in rescuing victims.

P.E. 2160. Water Safety Instructor Course
1-3-2. Prerequisite: current advanced lifesaving certificate and pass swimmer course skills.

Acquisition of motor skills and the mastery of methods of teaching lifesaving and swimming courses. Instruction in other aquatic activities such as pool operations, pool management, life-guarding and swimming and diving coaching.

PHYSICS

Phys. 1000. Physics Orientation
1-0-1.

Guest lectures will describe career opportunities in physics, the role physicists play in education, government and industrial laboratories, and programs available to physics majors.

Phys. 1001. Survey of Great Advances in Modern Physics
1-0-1.

A series of lectures, each of which deals with an important area of physics research or application; e.g., superconductivity, lasers, nuclear structure and energy, transistors.

Phys. 2001. Physics of Space and Time
3-0-3. Prerequisite: Phys. 2121 or 2111.

An introduction to special and general relativity. Principle of relativity. Speed of light. Space contraction. Time dilation. Mass, momentum and energy. Principle of equivalence.

Text: at the level of Einstein, *Relativity, the Special and the General Theory*.

Phys. 2010. Physics of the Weather
3-0-3.

An introductory treatment of the application of the basic physical laws to the understanding of weather phenomena. The main weather features will be descriptively developed.

Text: at the level of Riehl, *Introduction to the Atmosphere*.

Phys. 2021. Introduction to Astronomy I
3-0-3.

The nature and behavior of the earth and the other members of the solar system will be examined.

Text: at the level of Abell, *Exploration of the Universe*.

Phys. 2022. Introduction to Astronomy II
3-0-3. (Phys. 2021 is not a prerequisite for Phys. 2022.)

The nature and behavior of the stars and galaxies will be examined.

Text: at the level of Abell, *Exploration of the Universe*.

Phys. 2030. Physics of Music
3-0-3.

A descriptive introduction to the physical principles of the various sources of musical tones, how the sounds are generated, transmitted and received by the listener.

Text: at the level of Rigden, *Physics and the Sound of Music*.

Phys. 2111-2-3. Elementary College Physics
4-0-4 each. Phys. 2111 should be taken first; Phys. 2112 and 2113 may be taken in either order, but it is preferable that 2112 precede 2113.

Basic study of the physical principles of mechanics, sound, heat, electricity, light and modern physics for students in the less technical curricula. Method of teaching and subject matter chosen to give an understanding of scientific methods and a background of scientific information needed to comprehend the commercial, cultural and political significance of scientific progress.

Text: at the level of Hooper and Gwynne, *Physics and the Physical Perspective*.

Phys. 2121. Particle Dynamics
4-3-5. Corequisite: Math. 1309.

Introduction to classical mechanics. Topics include kinematics, dynamics, energy, momentum and rotational motion. Laboratory based on frictionless surfaces and stroboscopic photographic equipment emphasizes data analysis.

Text: at the level of Halliday and Resnick, *Fundamentals of Physics*.

Phys. 2122. Electromagnetism

4-3-5. Prerequisite: Phys. 2121; corequisite: Math. 2307.

Topics include electric field, potential, magnetic field and electromagnetic induction. Calculus and vectors are used. The laboratory stresses use of electrical instruments including oscilloscopes.

Text: at the level of Halliday and Resnick, *Fundamentals of Physics*.

Phys. 2123. Optics and Modern Physics
4-3-5. Prerequisite: Phys. 2122 and Math. 2307.

Wave propagation, interference, diffraction and polarization. Geometrical optics. Particle aspects of electromagnetic radiation and wave aspects of material particles. Bohr model. Laboratory illustrates wave propagation.

Text: at the level of Halliday and Resnick, *Fundamentals of Physics*.

Phys. 2801-2-3-4-5. Special Topics

1-0-1 to 5-0-5 respectively.

Courses in special topics of current interest in physics are presented from time to time.

Phys. 2900-1-2. Special Problems

Credit to be arranged. Prerequisite: consent of school.

Phys. 3001. Introductory Modern Physics

5-0-5. Prerequisite: Phys. 2123.

Survey of principles and phenomenology of modern physics, including atomic structure, nuclear phenomena and the interaction of radiation with matter.

Text: at the level of Weidner and Sells, *Elementary Modern Physics*.

Phys. 3003. Breakthroughs in Physics

3-0-3. Prerequisite: Phys. 2113 or 2123.

A historical approach to the development of quantum theory with emphasis on the physical meaning. Applications to currently important areas including lasers and elementary particles.

Text: at the level of Silva and Lochak, *Quanta*.

Phys. 3021. Nuclear Astrophysics and Stellar Evolution

3-0-3. Prerequisite: Phys. 2123.

Nucleosynthesis and energy generation in stars, stellar models and stellar evolution. Formation of elements, supernovae, quasars, neutron stars, "black-holes" and radio sources. All majors.

Text: at the level of Fowler, *Nuclear Astrophysics*.

Phys. 3121-2-3. Classical Mechanics, Electricity and Magnetism

5-0-5 each. Prerequisite: Phys. 2123, Math. 2309 concurrent with 3121, courses to be taken in sequence.

Dynamics of particles including oscillations and planetary motion, rotation of rigid bodies, collisions, Lagrange's equations. Electric and magnetic fields, potentials, resistance, inductance and capacitance, polarization, magnetic materials, development of Maxwell's equations and their application to the transmission of electromagnetic waves.

Text: at the level of Symon, *Mechanics* and

Lorrain and Corson, *Introduction to Electromagnetic Fields and Waves*.

Phys. 3133 Mechanics

5-0-5. Prerequisite: Phys. 2123.

Mechanics of particles and rigid bodies, gravitation, moments of inertia, the conservation laws, hydrodynamics, elasticity and stress and strain.

Text: at the level of Kleppner and Kolenkow, *An Introduction to Mechanics*.

Phys. 3134. Intermediate Electricity and Magnetism

5-0-5. Prerequisite: Phys. 2123.

Maxwell's equations and applications. Electrostatics, dielectrics, magnetostatics, magnetic substances, Ampere's and Faraday's laws, electrical circuits.

Text: at the level of Lorrain and Corson, *Electromagnetism*.

Phys. 3138. Quantum Physics

5-0-5. Prerequisite: Phys. 2123.

Background to the development of quantum mechanics. Analysis of one dimensional problems. Applications of quantum mechanical concepts to atomic, molecular and solid state physics.

Text: at the level of Eisberg and Resnick, *Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles*.

Phys. 3141. Thermal Physics

5-0-5. Prerequisite: Phys. 2123 and Math. 2308.

Thermodynamics and introduction to statistical mechanics. Heat, temperature, entropy. Reversible, irreversible and quasi-static processes. Thermodynamic potentials. Magnetic thermodynamics. Maxwell-Boltzmann distribution. Microcanonical and canonical ensembles.

Text: at the level of Callen, *Thermodynamics*.

Phys. 3143. Quantum Mechanics I

5-0-5. Prerequisite: Phys. 3121 or 3133 and Math. 2309.

Historical approach to wave mechanics. Operator, eigenfunction-eigenvalue problem solutions to Schrodinger's equation, free particle, particle in a box, the square well, harmonic oscillator, rigid rotator and hydrogen atom.

Text: at the level of Eisberg, *Fundamentals of Modern Physics*.

Phys. 3145. Introductory Statistical Physics

3-0-3. Prerequisite: Phys. 2123.

Introduction to the concepts and principles of statistical physics necessary for a microscopic understanding of thermodynamics and related macroscopic phenomena.

Text: at the level of Kittel, *Thermal Physics*.

Phys. 3211. Electronics

5-6-7. Prerequisite: Phys. 2123.

A.C. circuit theory and basic principles of amplifiers and other electronic circuits.

Text: at the level of Brophy, *Basic Electronics for Scientists*.

Phys. 3223. Geometrical Optics

3-0-3. Prerequisite: Phys. 2123 and Math. 2308.

Development of optical analysis of lenses and reflectors using matrix theory. Coverage includes image formation, stops, aberrations, photometry and analysis of typical optical systems.

Text: at the level of Blaker, *Geometric Optics*.

Phys. 3224. Optical Instruments Laboratory

1-3-2. Corequisite: Phys. 3223.

Use of optical instruments for purposes of observation and measurement. Instrumentation includes spectrometers, interferometers, nodal slides, microscopes and telescopes.

Phys. 3225. Foulter Optics

3-0-3. Prerequisite: Phys. 2123 and Math. 2308.

A discussion of physical optics using Fresnel-Kirchhoff integral equation. Abbe theory of image formation. Coherence, polarization. Maxwell equations as the basis for physical optics.

Text: at the level of Hecht and Zajac, *Optics*.

Phys. 3226. Advanced Optical Physics Laboratory

1-3-2. Corequisite: Phys. 3225.

Optional laboratory taken with Phys 3225. A small number of experiments designed to exemplify the material presented in lecture course.

Phys. 3229. Vacuum Ultraviolet Optics

1-3-2. Prerequisite: Phys. 2123.

Laboratory and lecture concerned with sources, dispersion techniques and detectors in the approximate wavelength region of 100 to 2000 Angstrom units.

Text: at the level of Sampson, *Techniques of Vacuum Ultraviolet Spectroscopy*.

Phys. 3230. Photographic Principles.

2-3-3. Prerequisite: Phys. 2113 or 2123.

Lectures and demonstration (laboratory) period. Relationship of photographic practice and scientific principles: photographic optics, photometry, perspective control, monochrome and color images and processing, image quality.

Text: at the level of Langford, *Basic Photography and Advanced Photography*.

Phys. 3241. Elementary Biophysics I

3-0-3. Prerequisite: Phys. 2123.

Applications of the principles and techniques of the physical sciences to areas of the life sciences.

Text: at the level of Stanford, *Foundations of Biophysics*.

Phys. 3243. Elementary Biophysics II

3-0-3. Prerequisite: Phys. 3241

A continuation of topics from Physics 3241. Physics of viruses, the central nervous system and biophysical instrumentation.

Text: at the level of Stanford, *Foundations of Biophysics*.

Phys. 3261. Introduction to Elementary Particle Physics

3-0-3. Prerequisite: Phys. 2123.

Phenomenology of elementary particles. Historical introduction, list of particles, quantum numbers, conservation laws, selection rules, cross sections, decays, strong, electromagnetic, weak interactions: S-matrix, quantum field theory, models.

Text: at the level of Perkins, *Introduction to High Energy Physics*.

Phys. 3263. Computers in Physics

1-6-3. Prerequisite: Phys. 2123.

Computer solutions of realistic physics problems which use a variety of numerical techniques, including integration, solution of simultaneous algebraic equations and solution of differential equations.

Phys. 3264. Computer Analysis of Physics Data

1-6-3. Prerequisite: Phys. 2123.

Computer analysis and acquisition of experimental data from physics experiments, including an introduction to on-line experiment control.

Phys. 3265. Introduction to Acoustics

3-0-3. Prerequisite: Phys. 2112 or 2122.

An introduction to the art and science of acoustics for students of varied backgrounds and interests. The emphasis is on the basic physical mechanisms which underlie all acoustical phenomena.

Text: at the level of Kinsler, *Fundamentals of Acoustics*.

Phys. 3751. Laser Physics

3-0-3. Prerequisite: Phys. 2123.

Principles of laser operation. Types of lasers. Survey lectures on the application of lasers to various fields. Course intended for both physics and non-physics majors. Phys. 3751 is the same as E.E. 4751.

Text: at the level of O'Shea, Callen and Rhodes, *Introduction to Lasers and Their Application*.

Phys. 3801-2-3-4-5. Special Topics.

1-0-1 to 5-0-5 respectively.

Courses in special topics of current interest in physics are presented from time to time.

Phys. 3900-1-2. Special Problems

Credit to be arranged. Prerequisite: consent of school.

Phys. 4001. Development of Quantum Theory

5-0-5. Prerequisite: Phys. 3138 or 3143 or equivalent.

An exposition of the historical development of quantum theory and an introduction to philosophical problems of quantum theory.

Text: at the level of Jammer, *The Conceptual Development of Quantum Mechanics*; important original papers.

Phys. 4143. Quantum Mechanics II

5-0-5. Prerequisite: Phys. 3143 or equivalent.

Introduction to perturbation theory, identical particles, spin and semiclassical radiation theory. Applications to atomic physics.

Text: at the level of Park, *Introduction to Quantum Theory*.

Phys. 4145. Special Relativity

3-0-3. Prerequisite: Phys. 3123 or 3134.

Critique of Newtonian mechanics and Maxwell's equations. Postulates and development of Einstein's theory. Four-vector notation and relativistic mechanics.

Text: at the level of Sard, *Relativistic Mechanics*.

Phys. 4206. Interfacing Laboratory I

3-3-4. Prerequisite: Phys. 3211 or equivalent.

Introduction to the interfacing of computers with scientific apparatus. A computer and a variety of interfacing logic are available for the laboratory.

Phys. 4211. Electronic Instruments for Scientific Research

2-3-3. Prerequisite: Phys. 3211 or equivalent.

An intermediate course in electronic instruments and instrumentation as employed in research and general laboratory measurements.

Text: at the level of Littauer, *Pulse Electronics*.

Phys. 4212. Electronics Laboratory

0-3-1. Prerequisite: Phys. 3211 or equivalent.

Problems and techniques associated with the construction, calibration and maintenance of electronic instruments. Experience gained through actual construction, calibration and troubleshooting exercises.

Phys. 4213. Physical Measurements

3-0-3. Prerequisite: Phys. 3211 or equivalent.

Theory and techniques of measurement of fundamental electric and magnetic quantities under both static and dynamic conditions.

Phys. 4214. Physical Measurements Laboratory

0-3-1. Corequisite: Phys. 4213.

Taken at student's option with Phys. 4213. A set of laboratory exercises exemplifying and reinforcing material presented in the lecture course.

Phys. 4216. Interfacing Laboratory II

1-6-3. Prerequisite: Phys. 4206 or consent of school.

A continuation of Phys. 4206. Emphasis on individual student design and construction of interfaces for on-line control of experiments.

Phys. 4220. Optical Design

3-3-4. Prerequisite: Phys. 3223 or consent of school.

Principles of optical design, ray tracing and third order aberrations; laboratory stresses optical testing using conventional resolution tests and modulation transfer function.

Text: at the level of Smith, *Optical Engineering*.

Phys. 4221. Optical Fabrication

2-6-4. Prerequisite: Phys. 3223 or consent of school.

Theory and practice of vacuum deposition of metal and multi-layer thin films and of grinding and polishing optical elements.

Text: at the level of Horne, *Optical Production Technology*.

Phys. 4229. Seminar in Contemporary Optics

1-0-1. Prerequisite: consent of school.

Recent developments in optics discussed orally and summarized in written reports.

Phys. 4251. Biophysics I

3-0-3. Prerequisite: Phys. 2123, Biol. 2211.

An introduction to biophysical systems, first through the study of physical properties of biological macromolecules and then through selected studies of sensory systems in animals.

Text: at the level of Lehniger, *Bioenergetics*.

Phys. 4252. Biophysics II

3-0-3. Prerequisite: Phys. 4251.

Selected topics that stress the application of the measurement and analytical techniques of the physical sciences to studies of living systems.

Phys. 4253. Biophysics Laboratory

0-3-1. Corequisite: Phys. 4252.

This laboratory is taken at the student's option with Phys. 4252. Selected exercises exemplifying and reinforcing material presented in the lecture course.

Phys. 4261. Atomic Physics

5-0-5. Prerequisite: Phys. 3138 or 3143 or equivalent.

The structure and spectra of ordinary atoms, mesic atoms and positronium. Atomic beams techniques. Double resonance and level-crossing spectroscopy. Optical pumping. Properties of leptons.

Text: at the level of Woodgate, *Elementary Atomic Structure*.

Phys. 4262. Molecular and Solid State Physics

5-0-5. Prerequisite: Phys. 3138 or 3143; Phys. 3141 or Chem. 2113.

Application of quantum mechanics to molecules and solids. Molecular bonding and spectra of diatomic molecules. Binding forces and bond theory in solids. Applications to solid state devices.

Text: at the level of Ashcroft and Mermin, *Solid State Physics*.

Phys. 4263. Nuclear Physics

5-0-5. Prerequisite: Phys. 3138 or 3143.

Basic properties of nuclei, interactions of radiation with matter, accelerators, radioactivity, nuclear reactions, nuclear models, elementary particles.

Text: at the level of Evans, *The Atomic Nucleus*.

Phys. 4264. Plasma Physics

5-0-5. Prerequisite: Phys. 3123 or 3134.

Basic treatment of the plasma state via the Boltzmann equation, including collisions. Debye shielding length, diffusion, conductivity, oscillations and propagation of EM waves.

Text: at the level of Holt and Haskell, *Foundations of Plasma Dynamics*.

Phys. 4265. Transport Phenomena in Solids

3-6-5. Prerequisite: Phys. 2123; Phys. 3141 or Chem. 2113 or equivalent.

This course emphasizes an experimental approach to transport phenomena. Topics include electrical and thermal conductivity and related phenomena in metals, semiconductors and insulators.

Phys. 4266. Introductory Diffraction Studies

2-6-4. Prerequisite: senior standing or consent of school.

Introductory theory and practice of the most widely applicable X-ray and neutron diffraction techniques. Topics emphasized include identification, lattice parameters, textures, line breadth and crystal orientation.

Text: at the level of Azaroff, *Elements of X-ray Crystallography*.

Phys. 4271. Stellar and Planetary Atmospheres

5-0-5. Prerequisite: Phys. 2123.

Essentials of physics necessary for interpreting stellar and planetary atmospheres and other astrophysical plasmas. Solar radiation, chemical change, atmospheric temperatures and evolution of atmospheres.

Text: at the level of Aller, *Astrophysics*.

Phys. 4321-2. Advanced Laboratory I, II.

1-6-3 each. Corequisite: Phys. 3138 or 3143.

May be scheduled in either order. Experiment of classical and contemporary importance selected from various fields of physics. Experiments frequently deal with topics that have not been treated in other courses. Students will be expected to acquire an understanding of significance of experiments through independent study.

Phys. 4801-2-3-4-5. Special Topics

1-0-1 to 5-0-5 respectively.

Courses in special topics of current interest in physics are presented from time to time.

Phys. 4900-1-2. Special Problems

Credit to be arranged. Prerequisite: consent of school.

Phys. 6005. Computer Facilities for Graduate Research in Physics

1-6-3.

Introduction to the computational aspects of physics research and the characteristics of the computing systems available.

Phys. 6011. Principles of Nuclear Physics

4-0-4.

Radioactive decay and decay processes, interaction of radiation, statistical considerations in interactions, nuclear structure, stability and models, nuclear reactions and cross sections, properties of neutrons.

Text: at the level of Friedlander, Kennedy and Miller, *Nuclear and Radio Chemistry*.

Phys. 6121. Theoretical Mechanics

5-0-5.

Dynamics of particles and rigid bodies, including developments and applications of Lagrange's, Hamilton's and Euler's equations. Potential theory. Gyroscopic motion. Poisson brackets, Hamilton-Jacobi theory.

Text: at the level of Goldstein, *Classical Mechanics*.

Phys. 6122. Electrodynamics

5-0-5.

Discussion of Maxwell's equations, scalar and vector potentials, conservation laws, multipole

moments and multipole radiation, dispersion.

Text: at the level of Jackson, *Classical Electrodynamics*.

Phys. 6123. Statistical Mechanics

5-0-5. Corequisite: Phys. 6121.

Physical applications of probability theory. Classical and quantum statistical mechanics with numerous applications: ideal gas, imperfect gas, liquids and solids.

Text: at the level of Reif, *Fundamentals of Statistical and Thermal Physics*.

Phys. 6131. Mechanics of Continuous Media

3-0-3.

Dynamics of deformable bodies. Strain and stress, waves. Hydrodynamics of fluids: Bernoulli's theorem, Stokes' law, waves, vortex motion, viscous fluids.

Text: at the level of Trefil, *Introduction to the Physics of Fluids and Solids*.

Phys. 6132. Advanced Electricity and Magnetism

5-0-5.

A study of Maxwell's equations with applications to problems in electrical power systems, communications, signal processing, radiation and electrical measurements.

Phys. 6141. Quantum Mechanics I

5-0-5. Prerequisite: Phys. 4143 or equivalent.

Nonrelativistic quantum mechanics. Representation of dynamical variables as operators or matrices, theory of angular momentum, perturbation theory, selected topics from radiation and scattering theory.

Text: at the level of Merzbacher, *Quantum Mechanics*.

Phys. 6142. Quantum Mechanics II

5-0-5. Prerequisite: Phys. 6141.

Relativistic quantum mechanics, Dirac theory, the Lorentz group, antiparticles, relativistic Hamiltonians, propagators, Feynman graphs.

Text: at the level of Borken and Drell, *Relativistic Quantum Mechanics*.

Phys. 6143. Quantum Mechanics III

5-0-5. Prerequisite: Phys. 6141.

A problem-solving course that applies principles of quantum mechanics to atomic, molecular, solid-state and nuclear physics.

Phys. 6231. Introductory Solid State Physics

3-0-3.

Brillouin zone treatment of metals, semiconductors, insulators. Approximation methods for estimating properties of real solids. Comparisons between theory and experiment for selected solid state phenomena.

Text: at the level of Kittel, *Introduction to Solid State Physics*.

Phys. 6233. Physical Crystallography

3-0-3. Prerequisite: Phys. 4266 or equivalent.

Experimental and analytical aspects of X-ray, neutron and electron diffraction crystallography applied to problems such as physical property mechanisms, defects and other topics of current physical interest.

Phys. 6251. Diatomic Molecules

3-0-3. Prerequisite: Phys. 4143 or equivalent.

Electronic structure, calculation of potential energy curves, absorption parameters, emission parameters, rotational line strengths, vibrational band strengths, calculation of Franck-Condon factors.

Phys. 6263. An Introduction to Collision Theory

3-0-3. Prerequisite: Phys. 4143 or equivalent.

Quantum theory of nonrelativistic elastic and inelastic scattering, rearrangement collisions, central, nonlocal, absorptive interactions, phase shift analysis, variational methods, semiclassical and impulse approximations, transition probabilities.

Phys. 6264. The Theory of Atomic Collisions

3-0-3.

Collisional excitation and ionization involving electrons, atoms and molecules. Charge-transfer, recombination, ion-molecule reactions. Atomic processes in planetary atmospheres in astrophysics and in laboratory plasmas.

Phys. 6267. Atomic Collisions

3-0-3.

A discussion of the techniques by which atomic collisions phenomena are studied, includes scattering of ions and electrons in gases and scattering from solid surfaces. Also taught as E.E. 6760.

Phys. 6300. Graduate Laboratory

1-6-3.

Students choose a program of several experiments from those available in varied fields such as nuclear physics, solid state physics, X-ray diffraction, optics and physics instrumentation.

Phys. 7000. Master's Thesis**Phys. 7123. Statistical Mechanics II**

5-0-5. Prerequisite: Phys. 6123.

An advanced course in statistical mechanics, including problems of biological significance.

Phys. 7125. Introduction to Relativity

5-0-5. Prerequisite: Phys. 6121, 6122.

Reference frames and transformations, tensor

calculus, review of special relativity, electrodynamics, the principle of equivalence, general relativity and gravitation, cosmologies and black holes.

Phys. 7126. Gravity

5-0-5. Prerequisite: Phys. 7125.

Gravitational waves. Experimental tests. Petrov classes. Spinors. Twistors. Simplicial approximations.

Phys. 7141. Quantum Mechanics of Many-Particle Systems

5-0-5. Prerequisite: Phys. 6141.

Interacting systems of particles described quantum mechanically using the method of second quantization. Application to Fermi and Bose systems.

Phys. 7143. Group Theory and Quantum Mechanics

5-0-5. Prerequisite: Phys. 6141 or equivalent.

Basic principles of group theory and the representation of groups by matrices. Applications will include atomic and molecular structure.

Phys. 7147. Quantum Field Theory

5-0-5. Prerequisite: Phys. 6141, 6122.

Quantum theory of free fields: scalar, vector and spinor fields. Conservation laws. S-matrix. Quantum electrodynamics.

Phys. 7261. Optical Properties of Solids

3-0-3. Prerequisite: Phys. 6231.

Classical treatment of dielectrics and metals. Fresnel equations and Kramers-Kronig relation. Quantum mechanical treatment of selected topics. Emphasis on experimental determination of optical constants.

Phys. 7263. Nuclear Physics

5-0-5. Prerequisite: Phys. 6141.

Use of nuclear models in computation of observable nuclear phenomena, including static and dynamic electromagnetic properties of nuclei.

Phys. 7265. Neutron Investigation of Condensed Matter

3-0-3. Prerequisite: Phys. 6141.

Time-dependent correlation functions and dynamic structure factors. Coherent and incoherent, elastic and inelastic scattering cross sections. Applications to neutron scattering by photons, magnetic interactions, fluids.

Phys. 7999. Preparation for the Comprehensive Examination

Phys. 8001-2-3. Graduate Student Seminar
1-0-1.

Intended mainly for beginning graduate stu-

dents. There are two series of seminars. Representative research programs in the school are described by advanced graduate students, postdoctorals and faculty members. The experimental basis of physics is illustrated through accounts of great experiments of importance to contemporary research.

Phys. 8011-2-3. Physics Seminar
1-0-0.

Phys. 8101-2-3-4-5. Special Topics
1-0-1 to 5-0-5 respectively.

Courses in special topics of current interest in physics are presented from time to time.

Phys. 8501-2-3. Special Problems
Credit to be arranged.

Phys. 8511-2-3. Special Problems
Credit to be arranged.

Phys. 8521-2-3. Special Problems in Condensed Matter Physics
Credit to be arranged.

Independent investigations, under the supervision of appropriate faculty members, in the area of condensed matter physics.

Phys. 8531-2-3. Special Problems in Acoustics
Credit to be arranged.

Independent investigations, under the supervision of appropriate faculty members, in the area of acoustics.

Phys. 8541-2-3. Special Problems in Applied Optics
Credit to be arranged.

Independent investigations, under the supervision of appropriate faculty members, in the area of applied optics.

Phys. 8551-2-3. Special Problems in Physics Instrumentation
Credit to be arranged.

Independent investigations, under the supervision of appropriate faculty members, in the instrumentation associated with experimental research in physics.

Phys 8999. Preparation for Doctoral Dissertation
Noncredit. Prerequisite: consent of department.

Phys. 9000. Doctoral Thesis

POLITICAL SCIENCE

See Social Sciences.

PSYCHOLOGY

Psy. 3300. Psychology and Contemporary Issues in Society
3-0-3

Contributions of psychology to an appreciation of selected contemporary issues. Topics may vary from quarter to quarter.

Psy. 3303. General Psychology A
3-0-3.

An intensive coverage of the methods and findings of contemporary psychology. Includes such topics as psychological development, learning, conditioning and biological bases of behavior.

Psy. 3304. General Psychology B
3-0-3. Prerequisite: Psy. 3303.

A continuation of Psy. 3303. Such topics as individual differences, perception, personality and social psychology will be discussed.

Psy. 4400. Developmental Psychology
3-0-3. Prerequisite: Psy. 3303.

A comprehensive study of human behavior and psychological development from infancy through adolescence. Emphasis is placed on empirical and cross-species contributions.

Psy. 4401. Industrial Psychology
3-0-3.

A survey of methods and findings in the scientific study of humans at work. Considered are such topics as selection, training, motivation, accidents and environmental effects.

Psy. 4402. Psychology of Adjustment
3-0-3. Prerequisite: Psy. 3303.

Consideration of characteristics and etiology of typical and atypical human behavior. A principal objective is an increased understanding of self and others.

Psy. 4403. Introduction to Psychological Testing.
3-0-3. Prerequisite: Psy. 3304 or 4401.

Consideration of the theoretical and practical issues in psychological measurement, with particular reference to psychological testing.

Psy. 4404. Psychology of Advertising
3-0-3. Prerequisite: Psy. 3303, 4401.

An analysis of psychological principles and techniques which serve as a foundation for effective advertising. The scientific study of consumer behavior is emphasized.

Psy. 4405. Seminar in Organizational Psychology
3-0-3. Prerequisite: Psy. 4401 or 4410.

Study of psychological factors in organizational functioning, including theoretical and research issues.

Psy. 4406. Psychological Statistics
2-3-3. Prerequisite: consent of school.

Application of statistical techniques to the design and analysis of psychological studies.

Psy. 4407. Experimental Psychology I
2-3-3. Prerequisite: Psy. 3303.

An introduction to psychological measurement and laboratory techniques used in the experimental study of topics such as sensory processes, perception, psychomotor performance and learning.

Psy 4409. Introduction to Engineering Psychology
3-0-3.

Engineering psychology is presented as an integral component in the design and evaluation of man/machine systems. Applied problems and general methodological questions are examined.

Psy. 4410. Social Psychology
3-0-3. Prerequisite: Psy. 3303.

Consideration of the behavior of the individual in relation to other individuals and groups.

Psy. 4411. Experimental Psychology II
3-3-4. Prerequisite: Psy. 3304, 4406, 4407 and consent of school.

Consideration of principles and research methods in the areas of learning and motivation with special emphasis on classical and operant conditioning of nonhuman animals.

Psy. 4412. Psychology of Learning
3-3-4. Prerequisite: Psy. 3304, 4406, 4407 and consent of school.

An empirical and theoretical analysis of human learning, memory and cognitive processes.

Psy. 4413. Applied Experimental Psychology
3-3-4. Prerequisite: Psy. 4406, 4412 and consent of school.

Consideration of the applications of the methods and data of experimental psychology.

Psy. 4421. Physiological Psychology
3-0-3. Prerequisite: Psy. 3304, Biol. 2211.

Neurophysiological, endocrinological and biochemical bases of sensory and motor functioning, learning, memory, motivation and behavior disorders.

Psy. 4422. Comparative Psychology
2-2-3. Prerequisite: Biol. 2211, Psy. 3304 and consent of school.

Consideration of principles and research meth-

ods of animal psychology and ethology. Literature reviews and reports, field trips and laboratory studies.

Psy. 4423. Introduction to Psycholinguistics
3-0-3. Prerequisite: consent of school.

A critical examination of current psychological research and theory in language development and behavior.

Psy. 4424. Introduction to Personality
3-0-3. Prerequisite: Psy. 3304 or Psy. 4410 and consent of school.

Introduction to and survey of major theories of personality.

Psy. 4425. The Psychology of Aging
3-0-3. Prerequisites: Senior or graduate standing, Psy. 3303 and 3304 or equivalent.

Current research findings and their theoretical and practical implications will be discussed. Interactions between adult age and a variety of psychological processes will be discussed: perception, memory, learning, cognition, personality, psychomotor skill, and psychophysiological processes.

Psy. 4491-2-3-4. Field Study of Animal Behavior
1-6-3 each. Prerequisite: Anthropology, Biology, or Psychology background; demonstrated interest in animal behavior; consent of instructor.

This course takes place in Kenya, East Africa, and is limited to fifteen qualified students. Lectures by the instructor and resident scientists will provide the in-class portion of the course. Visits to National Parks, Game Preserves, and lengthy in-field observation will introduce the students to the natural habitats of African animals.

Psy. 4750. Social Psychology-Sociology Measurement Seminar
3-0-3. Prerequisite: Psy. 4410 or equivalent and consent of school.

Problems, implications and methodologies relating to the measurement of individual and group behavior in social situations. Students will receive supervised project experience. Also taught as Soc. 4750.

Psy. 4751. Psychology and Environmental Design I
3-3-4. Prerequisite: consent of school.

Introduction to psychological concepts relevant to environmental design. Survey of selected methods for assessing man-made environment. Taught jointly by psychology and architecture faculty. Cross-listed as Arch. 4751.

Psy. 4752. Psychology and Environmental Design II

3-3-4. Prerequisite: Psy. 4751 and consent of school.

Continuation of Psy. 4751 with greater emphasis on independent research and development of design solutions to selected problems. Taught jointly by psychology and architecture faculty. Also taught as Arch. 4752.

Psy. 4754. Models of Human Information Processing

3-0-3. Prerequisite: Psy. 3303, 3304, I.C.S. 1700 or equivalent.

General and unified approaches to psychological and computer modeling of human information processes. Emphasis on neural, sensory, memory, semantic and conceptual processing. Also listed as I.C.S. 4754.

Psy. 4755. Sex Roles: Their Development and Cultural Influence.

3-0-3. Prerequisite: consent of school.

Psychological principles, legal facts and literary explications are integrated in an examination of the roles of men and women from three time perspectives: historical, current and future. Readings, lectures, discussions and invited panelists. Also listed as Engl. 4755 and Soc. Sci. 4755.

Psy. 4756. Human Factors in Software Development

3-0-3. Prerequisite: I.C.S. 2400 or equivalent; Psy. 3304.

Examines human factors in the software design and application process from initial requirement and specification statements to coding, testing, implementation and maintenance. Also taught as I.C.S. 4756.

Psy. 4800. Special Topics

1-3-2. Prerequisite: Psy. 3304, 4407 and consent of school.

Guided independent study in an area of psychology not represented in departmental course offerings.

Psy. 4802-3-4. Special Topics

2-0-2 through 4-0-4 respectively. Prerequisite: consent of school.

Special topics of current interest.

Psy. 4814. Special Topics

0-3-1. Prerequisite: Psy. 4406, 4411 and consent of school.

The student will, under the direction of a staff member, do semi-independent work in literature review and/or experimental design.

Psy. 4815. Special Topics

3-3-4. Prerequisite: consent of school.

Students will work, under the direction of the instructor, on projects adding to their development beyond the scope of existing courses.

Psy. 4900-1-2-3. Special Problems

Credit to be arranged. Prerequisite: consent of school.

Students engage in individual and group projects under the direction of a faculty member.

Psy. 4953. Special Problems in Psychological Aspects of Environmental Design

Credit to be arranged. Prerequisite: Psy. 4751, 4752 and consent of school.

Supervised individual study of problems relating to the interaction of environmental design and behavior.

Psy. 6601. Advanced Industrial Psychology

3-0-3. Prerequisite: Psy. 4401.

A survey of theoretical and pragmatic issues in industrial psychology. Recent developments and experimental findings will be discussed.

Psy. 6602. Applied Experimental Psychology

3-0-3. Prerequisite: Psy. 3304.

Consideration of the application of the methods and data of experimental psychology to the problems of man and the environment, emphasizing the engineering psychology approach.

Psy. 6603. Social Psychology

3-0-3. Prerequisite: six hours of psychology and consent of school.

A study of principles of social learning, motivation and perception and of attitudes and beliefs as they relate to behavior of individuals in groups.

Psy. 6604. Human Information Processing

3-0-3. Prerequisite: consent of school.

A study of information processing theories and measurement techniques as applied to psychological problems, emphasizing human perceptual, communication and learning processes.

Psy. 6605. Proseminar In General Psychology

3-0-3. Prerequisite: graduate standing and consent of school.

A comprehensive, advanced consideration of general psychology including such topics as conditioning, learning, memory and cognitive processes.

Psy. 6606. Proseminar In General Psychology

3-0-3. Prerequisite: graduate standing and consent of school.

A comprehensive, advanced consideration of general psychology including such topics as psy-

chological development, perception and physiological psychology.

Psy. 6607. Proseminar In General Psychology
3-0-3. Prerequisite: Psy. 6605, 6606 or equivalent and consent of school.

A continuation of Psy. 6605 and 6606 involving consideration of such topics as personality, individual differences and social psychology.

Psy. 6608. Human Motivation

3-0-3. Prerequisite: graduate standing, Psy. 6605 and consent of school.

Examines theoretical and pragmatic issues in the description and prediction of motivated behavior. Includes measurement problems, implications and applications in a range of settings.

Psy. 6609. Social Psychology of Organizations

3-0-3. Prerequisite: Psy. 4410 or equivalent and consent of school.

Selected topics from social psychology which are of particular significance to an understanding of individual behavior in an organizational context. Supervised readings and discussion.

Psy. 6610. Psychoacoustics

3-0-3. Prerequisite: Psy. 3304 or equivalent and consent of school.

A comprehensive coverage of physiological and psychological acoustics, including analyses of auditory and extra-auditory response mechanisms and evaluation of research and theories in hearing.

Psy. 6621-2. Foundations of Psychology

3-0-3 each. Prerequisite: graduate standing and consent of school.

A sequence involving historical and current points of view in psychology, emphasizing issues important for psychological theory.

Psy. 6623-4. Design of Psychological Experiments

2-3-3 each. Prerequisite: graduate standing. Math. 3710, Psy. 4406 or equivalent and consent of school.

A two-quarter sequence on the planning and implementation of research based on linear models, with reference to statistical considerations in data reduction and analysis.

Psy. 6625. Experimental Methods In Psychology

2-3-3. Prerequisite: graduate standing, Psy. 6605, 6606, 6623 or equivalent and consent of school.

Measuring the dependent variable in psychological experiments. Discussion is supplemented

by practice in designing, conducting and reporting experiments.

Psy. 6626. Response Evaluation

3-0-3. Prerequisite: graduate standing. Psy. 4406 or equivalent and consent of school.

Intensive consideration of theoretical and pragmatic problems in the description and evaluation of human responses in such areas as task analysis and performance measurement.

Psy. 6627. Human Learning

3-0-3. Prerequisite: graduate standing. Psy. 3303 or equivalent and consent of school.

A comprehensive consideration of principles, problems, methods and experimental data in the study of human learning, including discussion of applications of theory and experimental findings.

Psy. 6629. Psychomotor Skill Learning and Performance

3-0-3. Prerequisite: Psy. 4406, 6605, 6606 or equivalent.

Human capabilities and limitations for learning and performing psychomotor skills are studied. Emphasis is on performance measurement and assessment of skill proficiency, prediction and control.

Psy. 6630. Psychometric Theory

3-0-3. Prerequisite: Psy. 4403, 6624 or equivalent.

Preparation of students in statistical theory and techniques relevant to becoming professionally involved in construction, analysis and evaluation of psychological and personnel tests.

Psy. 6631. Personality and Social Development

3-0-3. Prerequisite: Psy. 6607 or equivalent.

The developmental aspects of personality and socialization in children are examined. Particular attention will be given to empirically derived data, assessment techniques and theoretical explanations.

Psy. 6632. Perceptual Development

3-0-3. Prerequisite: Psy. 6606 or equivalent.

Perceptual capabilities and experience are examined as they change across the life span. Special attention will be given to early development (infancy and childhood).

Psy. 6680. Multivariate Analysis

5-0-5. Prerequisite: Psy. 6624 or equivalent and consent of school.

Introduction to multivariate analysis in psychology with special emphasis on factor analysis.

Psy. 6750. Human-Computer Interface

3-0-3. Prerequisites: Permission of the department.

Human-computer interface is considered in terms of user-system compatibility. Concepts in human factors and interface design are covered in relation to capabilities and limitations of both humans and computers. Also taught as I.C.S. 6750.

Psy. 7000. Master's Thesis.

Psy. 7010. Seminar in Industrial Psychology

3-0-3. Prerequisite: Psy. 6601, 6607 and consent of school.

Critical and comprehensive examination of current problems in a selected area of industrial psychology. The area to be covered may vary from year to year.

Psy. 7011. Seminar in Experimental Psychology

3-0-3. Prerequisite: Psy. 6607, 6625 and consent of school.

Critical examination of current problems in a selected area of general experimental psychology. Area to be discussed may vary each time the course is offered.

Psy. 7012. Seminar in Engineering Psychology

3-0-3. Prerequisite: Psy. 6602, 6607 and consent of school.

Critical examination of current problems in a selected area of engineering psychology. The area to be discussed may vary each time the course is offered.

Psy. 7020. Advanced Learning

4-0-4. Prerequisite: graduate standing, Psy. 6605 or equivalent and consent of school.

An advanced and systematic examination of selected topics dealing with the experimental psychology of learning and memory. Theoretical approaches to learning, transfer and retention will be discussed.

Psy. 7021. Sensation and Perception

4-0-4. Prerequisite: Psy. 6606 or equivalent and consent of school.

An examination of human interpretation of physical stimulation. The student studies in some detail the nature of perceptual processes, including human sensory processes.

Psy. 7022. Vision

3-0-3. Prerequisite: Psy. 6606 or equivalent.

An advanced examination of the visual processes and the fundamental role they play in human behavior. Emphasis is placed upon objectively obtained data.

Psy. 7023. Operant Conditioning

4-0-4. Prerequisite: Psy. 6605 or equivalent.

Intensive treatment of methods, data and problem areas of operant conditioning. Among the topics covered are response differentiation, schedules of reinforcement and stimulus control.

Psy. 7024. Primate Behavior

3-0-3. Prerequisite: Graduate standing and consent of school.

A survey of research relating to primate behavior. A content course in which the major findings and theories of primate behavior will be considered; students will also discuss the methods employed in primate research, and observe selected species at the Yerkes Primate Research Center and Atlanta Zoological Park.

Psy. 7050. Professional Problems

2-0-2. Prerequisite: graduate standing and consent of school.

Introduces the student to professional problems which he or she may face as a psychologist, including teaching, professional practice and research. Ethical issues will be examined.

Psy. 7051. Teaching Practicum

1-3-2. Prerequisite: Psy. 7050.

Supervised college teaching for advanced graduate students in psychology. Discussion of teaching techniques, course and curriculum design in psychology and student evaluation is included in the course. Students will prepare and present lectures on selected topics in psychology courses. Direct observation and television taping will be used as a basis for class discussions.

Psy. 7750. Seminar on Psychology and Management

3-0-3. Prerequisite: Psy. 6601, 6609, I.M. 6150 or 6105 and consent of school.

Preparation and discussion of papers on management problems involving psychological complexities. Jointly taught by members of the psychology and industrial management faculties.

Psy. 8504. Special Problems in Industrial Psychology

Credit to be arranged. Prerequisite: Psy. 6601, 6602 or 6603.

Students will be expected to plan and execute a research problem involving investigation of some psychological aspect of management problems.

Psy. 8505. Special Problems in Experimental Psychology

Credit to be arranged. Prerequisite: consent of school.

Students conduct research under direction of a

faculty member on problems in the general area of experimental psychology.

Psy. 8506. Special Problems in Engineering Psychology

Credit to be arranged. Prerequisite: Psy. 6602 or equivalent and consent of school.

Students conduct research under direction of a faculty member on problems in the area of engineering psychology.

Psy. 9000. Doctoral Thesis

RUSSIAN

See Modern Languages.

SOCIAL SCIENCES

History

Hist. 1001. History of the United States to 1865

3-0-3.

A survey of the social, political and economic history of the United States through the Civil War with emphasis on selected topics. Gives exemption from U.S. and Georgia history examination.

Hist. 1002. History of the United States from 1865 to the Present

3-0-3.

A survey of the social, political and economic history of the United States from the Civil War to the present with emphasis on selected topics. Gives exemption from U.S. and Georgia history examination.

Hist. 1028. Introduction to the History of Science and Technology

3-0-3.

An introductory survey of the development of science and technology from antiquity to the present. Emphasis placed on sociocultural context and scientific and technological revolutions.

Hist. 3001. Origins of Modern Times: Western Civilization, 1500-1789

3-0-3.

An examination of the social, economic and political currents of early modern Europe. Among the themes covered are social developments and religious conflict, the emergence of a modern world economy, state centralization and the advent of the scientific revolution.

Hist. 3003. Nineteenth Century Europe
3-0-3.

This course traces the development of political ideologies, industrialization, labor activism, modern nation-state building and imperialism from the French Revolution to W.W. I.

Hist. 3004. World Problems Since 1914
3-0-3.

Various 20th century European themes to be examined in this course include the crisis of global war, communism, fascism and the movement for European integration.

Hist. 3010. History of the United States to 1865

3-0-3. Normally taken by juniors and seniors. Not open to students who have had Hist. 1001.

A survey of the special, political and economic history of the United States through the Civil War period with emphasis on selected topics. Gives exemption from the U.S. and Georgia history examination.

Hist. 3011. History of the United States from 1865 to the Present

3-0-3. Normally taken by juniors and seniors. Not open to students who have had Hist. 1002.

A survey of the social, political and economic history of the United States from the Civil War to the present with emphasis on selected topics. Gives exemption from U.S. and Georgia history examination.

Hist. 3012. History of Georgia

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

The problems which have confronted Georgia are examined in their historical settings. Relationship to the national scene gives perspective to the state's place in the nation.

Hist. 3013. United States Colonial History

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

Settlement and growth of the English colonies in North America with emphasis on the foundation of American political and economic institutions.

Hist. 3015. Survey of Sciences in the Sixteenth and Seventeenth Centuries

3-0-3.

An interpretative study of the scientific revolution including the social, economic and cultural context and origins of science in America.

Hist. 3016. Survey of Sciences in the Eighteenth and Nineteenth Centuries

3-0-3.

The evolution of science and scientific institu-

tions in Europe and the United States including rise of industrial research.

Hist. 3017. History of the Old South to 1865

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

A study of social, political and economic developments in the South from the colonial period through the Civil War.

Hist. 3018. History of the New South Since 1865

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

An examination of social, political and economic developments from the Reconstruction period to the present.

Hist. 3020. American Diplomatic History

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

American diplomatic history since the Revolutionary War with emphasis on developments in the twentieth century.

Hist. 3022. Afro-American History

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

Historical analysis of the black American from the ancient African beginnings to the present.

Hist. 3024. The American Civil War

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

A survey, with major emphasis on the military history of the war. Individual research is stressed.

Hist. 3025. American Economic History

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

Special attention given to the rise of technology, our industrial system, the westward movement, development of our banking system and government regulation of industry.

Hist. 3026. History of American Business
3-0-3.

Focuses on the development of business institutions from the colonial period up to the present. Themes stressed include the role of the entrepreneur, the emergence of "big business," the evolution of new business structures, government-business relations, and business and society.

Hist. 3028. United States Social and Intellectual History

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

Studies in the social and intellectual traditions

of the United States with emphasis on the more recent period. Assigned readings.

Hist. 3030. Technology and Economic Change
3-0-3.

Growth of technology in the modern world in its relationship to economic and social change.

Hist. 3037-8-9. History of Technology
3-0-3 each.

The development of technology from the beginnings of man to the present, with emphasis upon interrelations between technology and society.

Hist. 3040. Recent Latin American History
3-0-3.

An examination of the roots of contemporary Latin American issues such as underdevelopment and modernization; nationalism and interregional integration; and social structures and institutions. Consists of a general overview and case studies.

Hist. 3786. The Immigrant Experience

3-0-3. Prerequisite: Engl. 1001-2.

The history and literature of the immigrant, stressing life in the Old World and reasons for emigrating, the passage to America, impressions of the New World and problems of assimilation. Lectures, reports, papers.

Hist. 4008. History of Technology in the United States

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

A study of technology in America from the colonial period to the present including industrial and engineering history.

Hist. 4016. History of Electrical Science and Technology

3-0-3.

The origins and evolution of electrical science, technology and engineering. Emphasis placed on impact of major innovations in power, communications and electronics.

Hist. 4025. The United States Since 1917

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

Social, political, economic and diplomatic history of the United States in the middle of the twentieth century is examined as to causes, results and movements.

Hist. 4050. Twentieth Century Black History

3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

The inequities and achievements of the period

are dealt with through an analysis of selected topics.

Hist. 4075. The City in American History
3-0-3. Prerequisite: any one of Hist. 1001, 1002, 3010, 3011 or history examination.

Selected topics concerning the social, economic and political history of American cities with emphasis on the role of technology in urban development.

Hist. 4925-6-7-8-9. Special Problems in History

Credit to be arranged.

Philosophy of Science and Technology

P.S.T. 1126. Introduction to Philosophical Analysis
3-0-3.

An introduction to the nature of philosophy through critical study of selected works. The relation of philosophy to science, religion and society will be emphasized.

P.S.T. 1127. Science, Technology and Human Values
3-0-3.

An examination of the ways engineering technology shapes and is shaped by societal values. Also considers the appropriate and intermediate technology movements.

P.S.T. 3100. Introduction to Philosophical Analysis
3-0-3.

Through critical study of selected works the relation of philosophy to science, religion and society will be emphasized.

P.S.T. 3102. History of Ancient Philosophy
3-0-3.

A study of the development of philosophy from the early preSocratics' scientific writings to Christian thought. The works of Plato and Aristotle stressed.

P.S.T. 3103. History of Modern Philosophy
3-0-3.

The development of Western thought from Bacon to Kant, with emphasis on the philosophic dimensions of the rise of modern science.

P.S.T. 3104. Contemporary Philosophy
3-0-3.

A study of the diverse movements in philosophy from Hegel to Russell with emphasis on the philosophic response to the development of modern scientific inquiry.

P.S.T. 3105. Types of Ethical Theory
3-0-3.

Critical examination of ethical theories, consideration of theoretical problems of ethics, nature and presuppositions of ethical judgments, justification of ethical standards.

P.S.T. 3107. Comparative Religions
3-0-3.

Introduction to the development of the most important concepts in modern religious systems. Emphasis will be placed on the contributions of philosophical analysis and theological debate.

P.S.T. 3113. Symbolic Logic
3-0-3.

An introduction to the symbolic analysis of logical argument. Includes propositional calculus, truth-tables, truth-trees and methods of deduction.

P.S.T. 3120-1-2. Philosophy of Science
3-0-3 each.

A study of the main problems of philosophy of science including theories, explanation, prediction, causality, development of scientific knowledge, social and ethical aspects of science.

P.S.T. 4106. Philosophy of the Behavioral and Social Sciences

3-0-3. Prerequisite: senior standing or consent of the department.

Examination of philosophical views of social science, structural aspects of social science, relationship between natural and social science and other selected philosophical problems.

P.S.T. 4107. Philosophy of Technology

3-0-3. Prerequisite: senior standing or consent of the department.

A critical analysis of the methods, values and underlying philosophy of technology. Examines theories of social change and the role played by technology.

P.S.T. 4110. Theories of Knowledge
3-0-3.

Critical examination of perception, verification, *a priori* and *a posteriori* knowledge, meaning and criteria of truth, presuppositions and cognitive significance of scientific and philosophical propositions.

P.S.T. 4115. Philosophy of Science
3-0-3.

Examination of selected problems such as causality, inductions, scientific explanation, development of scientific knowledge, social and philosophical import of scientific theories.

P.S.T. 4120. Semantics

3-0-3. Normally taken by seniors.

The relations of formal logic and natural languages, sense and reference, semantical paradoxes, semantic criteria of truth.

P.S.T. 4757. Technology Assessment
3-0-3. Prerequisite: junior standing.

Systematic efforts to anticipate impacts on society that may occur when a technology is introduced, extended, or modified. Considers concepts, organization and uses of various specific assessment methods.

P.S.T. 4944-5-6-7-8. Selected Problems in the History of Science

Credit to be arranged.

P.S.T. 4949. Special Problems.
Credit to be arranged.

P.S.T. 8549. Special Problems
3-0-3.

Topics to be selected.

Political Science

Pol. 1251. Government of the United States
3-0-3.

Study of structure and function of governments of United States and Georgia. Gives exemption from United States and Georgia Constitution examination.

Pol. 1253. Comparative Political Systems
3-0-3.

Examination of current empirical political frameworks and conceptual vocabularies for purpose of developing common approach in analysis of individual political systems.

Pol. 2270. Introduction to Analysis of Political Behavior

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Introduction to political analysis; behavioral and post-behavioral perspectives. Explores basic concepts employed in selected theoretical approaches.

Pol. 2271. American Political Thought

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Examination and analysis of fundamental political ideas which have shaped the American political system.

Pol. 3200. American Constitutional Problems
3-0-3.

Study of structure and function of United States and Georgia government, taught largely

through medium of constitutional law. Gives exemption from United States and Georgia Constitution examination.

Pol. 3203. National Defense Policy

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Analysis of recent and current U.S. defense policy, including an examination of defense decision-making.

Pol. 3204. United States Military Policies

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Examination of the armed forces' relationship to society, with particular emphasis on the development of the military-industrial complex.

Pol. 3205. American Foreign Policy

3-0-3. Prerequisite: Pol. 1251 or consent of the department

Study of formulation and implementation of U.S. foreign policy, stressing economic, political and strategic factors.

Pol. 3210. National Legislative Processes

3-0-3. Prerequisite: Pol. 2270 or consent of the department.

Empirical and systematic analysis of national legislative branch with attention to relationships among executive branch, interest groups and Congress.

Pol. 3211. The American Presidency

3-0-3. Prerequisite: Pol. 1251, 2270 or consent of the department.

Source, nature and use of presidential power, the roles of the president. Recent historical examples emphasized.

Pol. 3215. Public Opinion

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Public opinion polling techniques, including sampling, questionnaire construction and interpretation. Analysis of actual opinion data collected on a national basis.

Pol. 3216. American Political Parties

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Study of political party developments and their role in the electoral process.

Pol. 3217. State and Local Government

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Analysis of structure and function of state, county and municipal government.

Pol. 3220. Urban Government and Political Problems

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

An examination of political institutions and processes in the urban setting, including metropolitan government and intergovernmental relations.

Pol. 3221. Urban Political Problems

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

A consideration of urban political behavior, including brokerage politics, politics in suburbia and community power structures.

Pol. 3222. Urban Public Policy

3-0-3. Prerequisite: Pol. 3220, 3221 or consent of the department.

An empirical and systematic analysis of selected urban public policy areas, including such policy areas as education, housing and crime control.

Pol. 3250. Public Administration and Public Policy

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Study of decision-making and organization theory, bureaucratic policymaking, intergovernmental relations, taxing and spending policy.

Pol. 3265. Latin American Governments and Politics
3-0-3.

A survey of governmental and political processes in Latin American countries.

Pol. 3266. The Developing Nations

3-0-3.

A study of selected underdeveloped nations including economic and political development.

Pol. 3270. Western European Governments and Politics
3-0-3.

Comparative analysis of governmental and political processes in the nations of Western Europe.

Pol. 3275. Foundations of National Power and International Relations

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Study of U.S. power position in world affairs.

Pol. 3276. International Organization

3-0-3. Prerequisite: Pol. 3275 or consent of the department.

Study of evolution, impact and future of international organizations.

Pol. 3280. Communist Political Systems
3-0-3.

An analysis of governmental and political processes in the communist governments.

Pol. 3281. Soviet Foreign Policy
3-0-3.

A study of formulation and conduct of Soviet foreign policy. Consideration of ideological, geopolitical influences, development of relations with Western world and the Third World.

Pol. 4200. Political Theory I
3-0-3.

A study of ancient, medieval, renaissance and reformation political philosophy.

Pol. 4201. Political Theory II
3-0-3.

The development of political philosophy from the seventeenth century age of reason through the nineteenth century age of ideology.

Pol. 4202. Political Theory III
3-0-3.

An analysis of contemporary political philosophy, emphasizing radical ideologies.

Pol. 4210. Science, Technology and Public Policy

3-0-3. Prerequisite: Pol. 1251 or consent of the department.

Examination of relationship between science and government including the effect of each area on the other in decision-making processes.

Pol. 4211. Science, Technology and World Politics
3-0-3.

An analysis of impact of science-technology on the international system: role of science and technology in foreign policy process.

Pol. 4250. Policy Analysis and Evaluation
3-0-3. Prerequisite: Pol. 3250 or consent of the department.

Study of the policy adviser in and out of government, social indicators and social accounting, evaluation of public policy, evaluation research techniques.

Pol. 4755. Sex Roles: Their Development and Cultural Influence
3-0-3.

Psychological principles, legal facts and literary explanations are integrated in an examination of the roles of men and women from three time perspectives: historical, current and future.

Pol. 4950, 4953-4-5-6. Special Problems in Political Science
Credit to be arranged.

Pol. 4951. Georgia Internship Program
Credit to be arranged (15 hours maximum).

Work-study program assigning student to project in state or local government. Student prepares research paper under jurisdiction of faculty member.

Pol. 4952. Legislative Intern Program
Credit to be arranged.

Service learning program combining an academic study of the legislative process with internship at Georgia Legislature in winter quarter. Interns selected competitively each year.

Pol. 6255. Governmental Aspects of Planning.
3-0-3.

Analysis and study of problems and solutions in the field of city planning.

Pol. 6951. Governor's Intern Program
Credit to be arranged.

Directed reading and research for students to work as interns in departments of state government.

Pol. 6952. Legislative Intern Program
Credit to be arranged.

Service learning program combining an academic study of the legislative process with internship at Georgia Legislature in winter quarter. Interns selected competitively each year.

Pol. 8574. Special Problems in Political Science
Credit to be arranged.
Topics to be selected.

Sociology

Soc. 1376. Introduction to the Principles of Sociology
3-0-3.

A study of basic social relations, including social structure and functions, analysis of social processes, the foundations of personality and analysis of social organization.

Soc. 1377. Social Institutions
3-0-3.

An analysis of the structure and functions of social institutions, including familial, educational, religious, economic and political. A study of institutional change and social disorganization.

Soc. 1378. Social Problems in a Changing Society
3-0-3.

Some major social problems of modern soci-

ety including crime, poverty, pollution, war, racism and urban unrest.

Soc. 3306. Urbanization
3-0-3. Prerequisite: Soc. 1376.

Growth of metropolitan communities, differentiation of functions, urban complexity, ecological areas, the city as a way of life, measures and trends in the process of urbanization.

Soc. 3308. Statistics for Planning
3-0-3.

Statistical principles for analysis of economic, social and population data, sampling, measures of central tendencies, normal curve, testing of findings, correlation and arriving at conclusions.

Soc. 3310. Demographic Analysis
3-0-3. Prerequisite: Soc. 1376, 3308.

Factors affecting population problems, population growth, fertility, mortality, migration, distribution and composition.

Soc. 3330. Ethnic Minorities in American Society
3-0-3. Prerequisite: Soc. 1376.

The principles of intergroup relations as they relate to the various racial and cultural groups in American society.

Soc. 3334. Social Stratification and Mobility
3-0-3. Prerequisite: Soc. 1376 or consent of the department.

Process of stratification, including the criteria for and characteristics of stratification. Implications of stratification for the functioning of society.

Soc. 3335. Social Problems of Industry
3-0-3. Prerequisite: Soc. 1376 or consent of the department.

A study of the nature of human relations in large-scale organizations, significance of authority, roles, communication, status and group norms in the work situation.

Soc. 3338. Individual and Society
3-0-3. Prerequisite: Soc. 1376 or consent of the department.

A study of the nature of interpersonal relations in small groups and in large social settings, a consideration of the problem of alienations and anomie.

Soc. 3339. Urban Sociology
3-0-3. Prerequisite: Soc. 1376.

Introduces student to basic concepts of sociology as applied to urban phenomena, nature of urbanism and consequences for social relations and human personality.

Soc. 3340. Urban Ecology and Demography
3-0-3. Prerequisite: Soc. 1376.

Involves application of ecological perspective to the study of urban phenomena, human spatial distribution theories of city location and patterns of city growth.

Soc. 3501. Sociology of Science
3-0-3. Prerequisite: Soc. 1376 or Soc. 1377 or consent of instructor.

Introduction to Science and Technology as a social and cultural phenomenon. Topics include: the cultural contexts of the roles played by scientists and engineers in contemporary society and the institutional tensions between science and government.

Soc. 3875-6-7. Special Topics
1-6-3.

Topics to be selected.

Soc. 4306. Technology and Society
3-0-3. Normally taken by seniors or graduate students.

Analysis of social conditions which promote or retard technological activity. Particular emphasis on the social role of the scientific and engineering professions in that development.

Soc. 4308. Seminar in Contemporary Urban Sociology

3-0-3. Prerequisite: Soc. 1376 and consent of the department.

Extensive and critical review of literature in the field in order to keep students abreast of latest thinking concerning urban phenomena and problems.

Soc. 4311. The Sociology of the Third World
3-0-3.

Principal focus on Third World countries as societies in development and thus affected by planning, technological innovation and policy activity. Discussion of development issues at both the national and family levels.

Soc. 4312. Seminar in Comparative Urban Development

3-0-3. Prerequisite: Soc. 1376 and consent of the department.

Entails cross-national comparison of cities and urban regions, appropriate models for understanding cities and urban regions and strategies for handling problems.

Soc. 4750. Social Psychology-Sociology Measurement Seminar

3-0-3. Prerequisite: Psy. 4410 or equivalent and consent of the department.

Problems, implications and applications relating to the measurement of individual and group behavior in social situations. Students will receive supervised project experience.

Soc. 4999. Special Problems in Sociology

Credit to be arranged.

Topics to be selected.

Soc. 6375. Planning for People

3-0-3.

Problems of planning with selected subgroups in urban societies: minorities, the aged, residents of the inner city, suburbanites, impact of environment on individuals and families.

Technology and Science Policy**T.A.S.P. 6001. Technology, Science and Society**

3-0-3.

An intensive survey of the key issues in the relationship between technology and society. Technology and science are analyzed as knowledge systems and social institutions through an examination of major theoretical perspectives and cases.

T.A.S.P. 6002. Policy Process and Analysis

3-0-3.

The major techniques and analytical approaches to the policy-making process at various levels of government and in the private sector.

T.A.S.P. 6003. Selected Socio-Technical Policy Issues

3-0-3.

A comprehensive study of current socio-technical policy issues with emphasis on the writing of reports simulating those typically encountered in the field.

T.A.S.P. 6011. Logic of Inquiry

3-0-3.

The first course in the methodology core sequence familiarizes the student with basic conceptual issues and techniques, and prepares one to design and evaluate research programs.

T.A.S.P. 6012. Research Design and Data Analysis

3-0-3. Prerequisites: T.A.S.P. 6001 and I.Sy.E. 6739.

Focuses on communication of specific strategies and techniques for designing policy-relevant projects, data gathering, and statistical analysis.

T.A.S.P. 6013. Data Analysis II and Forecasting

3-0-3. Prerequisite: T.A.S.P. 6012.

A continuation of data analysis, considering the general linear model and topics in multivariate analysis. Emphasis on the techniques of social forecasting.

T.A.S.P. 7000. Master's Thesis

A thesis meeting the Institute's requirements. Required.

SPANISH

See Modern Languages.

TEXTILE ENGINEERING**Text. 1100. Introduction to Textile Engineering**

3-0-3. Prerequisite or corequisite: Chem. 1101 or 1111.

An introduction to textile chemistry, textile engineering and textile management, textiles, fibers and polymers, and to the textile-fiber-polymer-chemical-equipment-engineering industrial complex. Credit can not be obtained for both Text. 1100 and Text. 2701.

Text. 2100. Introduction to Fiber Science

3-0-3.

Introduction to natural and man-made fibers, fiber structure and physical properties including elasticity, recovery, moisture sorption and optical properties.

Text. 2101. Yarn Processing I

3-0-3. Prerequisite: Text. 2100.

Fundamental principles of processing natural and man-made staple fibers into yarn and basic properties of spun yarn.

Text. 2102. Yarn Processing II

3-0-3. Prerequisite: Text. 2101 or consent of school.

Alternate methods for producing yarns from continuous filament and staple fiber.

Text. 2180 Textile Manufacturing Processes I

0-3-1. Prerequisite or corequisite: Text. 1100.

Orientation to manufacturing and management operations in the student operated enterprise.

Text. 2181. Textile Manufacturing Processes II

0-3-1. Prerequisite: Text. 2101 or consent of school.

Yarn production operations within the student operated enterprise.

Text. 2182. Textile Manufacturing Processes III

0-3-1. Prerequisite: Text. 3110 or consent of school.

Woven fabric production operations within the student operated enterprise.

Text. 2500. Survey of Apparel Manufacturing

3-0-3.

Apparel engineering and manufacturing from planning and receipt of raw materials to the distribution of finished garments.

Text. 2700. Survey of Polymer and Fiber Technology

3-0-3. Not open to textile students.

An introduction to the history, structure, properties, fabrication and use of polymers in the textile and related industries.

Text. 2701. Textile Industry Survey

3-0-3. Not open to textile students.

An overview of textiles, fibers and polymers and the associated complex of industries from raw materials to finished products including textile arts and textile management. Credit can not be obtained for both Text. 1100 and Text. 2701.

Text. 2702. Survey of Fibrous Materials

3-0-3. Not open to textile students.

A survey of natural and man-made fibers used in the textile industry.

Text. 3110. Woven Structures I

3-0-3. Prerequisite: Text. 2101.

The weaving process and woven fabric construction, design and properties are studied.

Text. 3111. Woven Structures II

3-0-3. Prerequisite: Text. 3110.

Dynamics, operating characteristics and economics of new weaving machines.

Text. 3112. Knit Fabrics

3-0-3. Prerequisite: Text. 2100.

A study of warp and weft knit fabric production, properties and design. Description of knitting machines as related to fabric design and control of properties.

Text. 3113. Nonwoven Fabrics

3-0-3. Prerequisite: Text. 2100.

Chemically and mechanically bonded nonwoven fabrics, fabric formation processes, design and properties.

Text. 3122. Structures of Organic Polymers

3-0-3. Prerequisite: Chem. 1102 or consent of school.

A study of the chemical and physical structures of organic, fiber-forming polymers and the relationship of their structure to properties.

Text. 3400. Computer Applications in Textiles

2-3-3. Prerequisite: Math. 1712 or 1308 or consent of school.

Computer techniques are applied to textile engineering problems. An assembler language in-

troduces FORTRAN. Applications include digital and analog interfaces to textile processes.

Text. 3480. Textile Manufacturing Processes IV

0-3-1. Prerequisite or corequisite: Text. 3112 or consent of school.

Knit fabric production operations within the student operated enterprise.

Text. 3481. Textile Manufacturing Processes V

0-3-1. Prerequisite: consent of school.

Evaluation of products produced by the student operated enterprise.

Text. 3482. Textile Manufacturing Processes VI

0-3-1. Prerequisite: Text. 4305 or consent of school.

Fabric finishing operations within the student operated enterprise.

Text. 3483. Problems in Textile Management I

0-3-1. Prerequisite: Mgt. 2000, Mgt. 3300 or consent of school.

Product marketing and cost accounting within the student operated enterprise.

Text. 3484. Problems in Textile Management II

0-3-1. Prerequisite: consent of school.

Methods of plant maintenance and work studies within the student operated enterprise.

Text. 3485. Problems in Textile Management III

0-3-1. Prerequisite: consent of school.

Personnel administration, scheduling and planning within the student operated enterprise.

Text. 3500. Jacquard Design and Weaving

2-3-3. Prerequisite: Text. 3110.

The designing of Jacquard patterns and the techniques involved in the transfer of design to the fabric.

Text. 3510. Materials Preparation, Pattern Analysis and Cutting in Garment Manufacture

3-0-3. Methods, mechanics and analysis of materials preparation, pattern drafting and cutting in garment manufacture with emphasis on new methods and automation.

Text. 3511. Garment Assembly

4-0-4.

Formation and mechanics of seaming including thread properties, stitch formation, sewing machines, heat sealing and ultrasonic, radio frequency, infrared and adhesive bonding.

Text. 3512. Apparel Production, Planning and Engineering

4-0-4. Prerequisite: Text. 3510 or consent of school.

Analysis and design of apparel production from raw materials to finished product with emphasis on maximizing quality and productivity and minimizing time, cost and waste.

Text. 3513. Apparel Shaping and Finishing

4-0-4. Prerequisite: Text. 3510, 3511 and 3512 or consent of school.

Principles and analysis of processes for shaping and finishing apparel with emphasis on design of systems and equipment for maximizing the quality/cost ratio.

Text. 3700. Survey of Fiber Processing

3-0-3. Not open to textile students.

A survey course in yarn manufacturing covering principles of processing natural and synthetic fibers.

Text. 3701. Survey of Fabric Production

3-0-3. Not open to textile students.

A survey of fabric assemblies including woven, knit, nonwoven and flexible composite structures. Discussion includes processing, design and mechanical behavior.

Text. 3702. Survey of Dyeing and Finishing of Textile Materials

3-0-3. Not open to textile students.

Dyeing and finishing of textile materials made from natural and synthetic fibers.

Text. 3750. Elementary Heat and Mass Transfer

3-0-3. Prerequisite: Math. 2308, Phys. 2123, M.E. 3720.

Unit operations of chemical engineering emphasizing applications to fibers and textiles.

Text. 3800. Special Topics

1-0-1. Prerequisite: consent of school.

Studies of topics of current interest and concern to the textile industry.

Text. 4100. Textile Management Decision-Making

2-3-3. Prerequisite: senior standing.

Students practice making management decisions in a competitive market using computer simulations of textile manufacturing operations.

Text. 4101. Planning and Control in Textile Production Systems.

3-0-3. Prerequisite: I.Sy.E. 3749.

A study of the basic planning and control functions required in textile production systems, including design of production facilities, analysis

and control of inventory systems and production planning.

Text. 4122. Chemical Structures and Physical Properties of Polymers

3-0-3. Prerequisite: Chem. 1102 or consent of school. Not open to textile chemists, chemists or chemical engineers.

A fundamental review of organic polymers, including polymerization methods, chemical structures and structure/property relationships.

Text. 4200. Fiber Science

3-0-3. Prerequisite: Phys. 2121 or 2111.

The physical structure and properties of fibers are examined and related to end-use performance.

Text. 4201. Mechanics of Fibrous Structures I

3-0-3. Prerequisite: Text. 4200 or consent of school.

Yarn processing with emphasis on relationships between fiber properties and yarn properties.

Text. 4202. Mechanics of Fibrous Structures II

3-0-3. Prerequisite: Text. 4201 or consent of school.

Processes, properties and mechanics involved in the manufacture of woven and knitted fabrics.

Text. 4203. Mechanics of Fibrous Structures III

3-0-3. Prerequisite: Text. 4201 or consent of school.

Investigation of production processes, structures and properties of adhesive and mechanically bonded nonwoven fabrics and fiber reinforced materials.

Text. 4300. The Chemistry and Chemical Processing of Fibers and Textiles I

3-0-3. Prerequisite: Text. 4751.

The structure and purification of natural and synthetic fibers with emphasis on the relationship of fiber structure and behavior during chemical processing.

Text. 4301. The Chemistry and Chemical Processing of Fibers and Textiles II

3-3-4. Prerequisite: Text. 4751 or consent of school.

The dyeing and printing of textile materials with emphasis on the relationship of fiber structure and response of textiles to these processes.

Text. 4302. Textile Finishing Processes

3-0-3. Prerequisite: Text. 4751 or consent of school.

The chemical and mechanical finishing of textile materials to impart desired properties with

emphasis on the relationship of fiber structure and response of textiles to these processes.

Text. 4305. Chemical Preparation and Finishing of Textiles

3-0-3. Prerequisites: Text. 3122 or Text. 4751 or consent of school.

The chemical, thermal and mechanical processes used in the preparation and finishing of fibers, yarns and fabrics.

Text. 4306. Dyeing and Printing

3-3-4. Prerequisites: Text. 3122 or Text. 4751 or consent of school.

The application of dyes and pigments to fibers, yarns and fabrics.

Text. 4310. Textile Instrumental Analysis

2-3-3. Prerequisite: consent of school.

The theory and practice of modern instrumental methods as used in the analysis of textile chemicals with emphasis on spectroscopy, chromatography, colorimetry and differential thermal analysis.

Text. 4401. Introduction to Textile Literature

1-0-1.

Sources of textile information and an introduction to search techniques for the textile information system.

Text. 4402-3-4. Seminar

1-0-0, 1-0-0, 1-0-1 respectively. Prerequisite: senior standing. 4402-3 are prerequisites for 4404.

Presentations by invited speakers on new developments in textiles, job opportunities and graduate education.

Text. 4420. Analysis of Textile Materials

3-3-4. Prerequisite: Text. 4200, 3122 or 4751, I.Sy.E. 3749 or consent of school.

The methods used in the textile industry for assessing the effects of process variables on the end use performance of textile products are examined.

Text. 4480. Problems in Production Supervision

0-3-1. Prerequisite: Text. 2180-1-2, 3480-1.

Supervision of the student operated enterprise production operations. Solving day to day problems in logistics, personnel relations and manufacturing technology.

Text. 4481. Advanced Problems in Textile Management

0-3-1. Prerequisite or corequisite: Text. 3483-4-5.

Supervision of one of the student operated enterprise's staff level departments.

Text. 4482. Product Innovation

0-3-1. Prerequisite or corequisite: Text. 4480.

The student is part of a small entrepreneurial team developing new products for the student operated enterprise.

Text. 4483. Special Problems in Textile Industrial Operations

0-6-2. Prerequisite: Text. 3702 or consent of school.

Available to textile and non-textile students who want to engage in special projects which involve the personnel or facilities of the student operated enterprise.

Text. 4500. Technology of Carpet Manufacturing

3-0-3.

A study of materials and production systems used in carpet manufacturing. Carpet performance characteristics, dyeing, backcoating and nonwoven carpet manufacturing methods are examined.

Text. 4502. Fiber Reinforced Materials

3-0-3. Prerequisite: consent of school.

Principles and engineering behavior of flexible and rigid fiber reinforced composites. Topics include influence of matrix, interface and voids, fabrication, fracture and fatigue characterization, evaluation of specific composite systems.

Text. 4503. Science of Color

3-0-3. Prerequisite: Chem. 1102, Phys. 2113 or consent of school.

The physical, chemical and biological principles involved in perception, measurement and specification of color.

Text. 4504. Fiber Extrusion, Drawing and Texturing

3-0-3. Prerequisite: Text. 3122, 4751 or consent of school.

Rheology, mechanics, energetics, kinetics, phase transitions and polymer structure in fiber formation by melt, dry, wet and reactive spinning, and drawing and texturing of fibers.

Text. 4505. Structure and Mechanics of Knit Fabrics

3-0-3. Prerequisite: Text. 3112 or consent of school.

The basic geometries of fabrics produced by warp and weft knitting, overall physical properties of knit fabrics and fabric stress distribution.

Text. 4750. Polymer Science and Engineering I

3-0-3. Prerequisite: Chem. 1102, Phys. 2113 or consent of school.

An introduction to the chemistry and structure of polymers. Polymerization processes, major polymer systems and methods of identification of

polymers are presented. Also taught as Ch.E. 4750.

Text. 4751. Polymer Science and Engineering II

3-0-3. Prerequisite: Text. 4750 or Ch.E. 4750 or consent of school.

An introduction to the physical states and transitions, fabrication processes and mechanical properties of polymers. Also taught as Ch.E. 4751.

Text. 4752. Polymer Science and Engineering Laboratory

0-3-1. Prerequisite: Text. 4751 or Ch.E. 4751.

Experiments in polymerization, processing and property evaluation of polymers. Also taught as Ch.E. 4752.

Text. 4753. Survey of Pulp and Paper Technology

3-0-3.

The mechanical systems used in paper manufacture. Chemistry of pulp preparation and nonfibrous additives. Also taught as Ch.E. 4753.

Text. 4773. Paper Formation and Properties

3-0-3. Prerequisite: consent of school.

The processes in the fabrication of paper and paper products from pulp. The effects on paper properties of chemical and mechanical pretreatment of pulp. The measurement of paper properties. Also taught as Ch.E. and M.E. 4773.

Text. 4800-1-2. Special Topics

3-0-3. each. Prerequisite: consent of school.

Studies of topics of current interest and concern to the textile industry.

Text. 4900-1. Special Problems

Credit to be arranged. Prerequisite: consent of school.

Special problems involving analytical and/or experimental investigations in the field of textiles.

Text. 6100. Advanced Fiber Science

3-0-3. Prerequisite: graduate standing.

Physical properties, mechanical properties and microstructure of polymeric fibers are examined and related to end-use performance.

Text. 6101. Textile Testing and Evaluation

3-3-4. Prerequisite: graduate standing.

Study of methods used to characterize properties that are important to an understanding of behavior of fibers, yarns and fabrics.

Text. 6200. Physical Methods of Investigating Textiles

3-6-5. Prerequisite: I.Sy.E. 3749, Text. 4420 or consent of school.

Study of modern techniques and instrumenta-

tion for the evaluation of physical properties of fibers, yarns and fabrics.

Text. 6201. Process Control in the Textile Industry

3-0-3. Prerequisite: Text. 6200 or consent of school.

Computer techniques are applied to problems in scheduling production equipment and in control of quality, inventories and production. Topics include interfacing, costs, programming.

Text. 6210. Dynamics of Fiber Processing Systems I

3-0-3. Prerequisite: Text. 4200, 4201 or consent of school.

The dynamic interaction of fibers and fiber assemblies during processing is examined. The effects of fiber and bundle properties on processing variables are analyzed.

Text. 6211-2 Dynamics of Fiber Processing Systems II, III

3-0-3 each. Prerequisite: Text. 6210 or consent of school.

The dynamics of fabric forming mechanisms are examined. Weaving, knitting, sewing, heating and drying are typical processes which are considered.

Text 6300. Preparation and Reactions of Polymers

3-0-3. Prerequisite: Text. 4750, 4751.

A detailed treatment of the reactions involved in the synthesis of both man-made and natural polymers including preparative and degradative reactions in polymer systems.

Text. 6320. Fundamental Aspects of Dyeing Processes

3-0-3. Prerequisite: Text. 4301 or 4306, 4751 or consent of school.

Models required for the interpretation of the dyeing behavior of textile materials are examined in order to provide useful semiquantitative descriptions of dye processes.

Text. 6321. Chemical Technology of Stabilization Processes

3-0-3. Prerequisite: Text. 4302 or 4305, 4751 or consent of school.

A comprehensive treatment of finishing processes used in the textile industry to impart desirable end-use performance characteristics to textile materials.

Text. 6400. Information Processes in Textile Science and Engineering

3-0-3. Prerequisite: Text. 3400 or consent of school.

Information aspects of textile science and technology; use of computers in acquisition, pro-

cessing and utilization of information and knowledge in textile research and production.

Text. 6750. Polymer Structure and Physical Properties I

3-0-3. Prerequisite: Text. 4751 or Ch.E. 4751 or consent of school.

Morphology and structure, linear and nonlinear viscoelasticity, anisotropic mechanical properties and yield and fracture behavior of polymers with applications to textile fibers and plastic products. Also taught as Ch.E. 6750.

Text. 6751. Polymer Structure and Physical Properties II

3-0-3. Prerequisite: Text. 6750 or Ch.E. 6750.

Structure-property relationships of elastomers, reinforced plastics, fibers, foams and natural polymers emphasizing proteins and the composite nature of all polymers and polymeric materials. Also taught as Ch.E. 6751.

Text. 7000. Master's Thesis

Text. 7210. Recent Advances in Textile Manufacturing

3-0-3. Prerequisite: consent of school.

A detailed review of significant new processes, techniques and machines in the textile industry.

Text. 7220. Fiber Mechanics

3-0-3. Prerequisite: Text. 4751 or consent of school.

The tensile, compressive, bending and torsional response of fibers. Fiber anisotropy and linear and nonlinear time dependent response are studied.

Text. 7221. Mechanics of Linear Assemblies

3-0-3. Prerequisite: Text. 4202 or consent of school.

The tensile, bending and torsional response of continuous filament, staple and blended singles yarns, the tensile response of plied yarns, cords and ropes, the tensile response of braided cords.

Text. 7222. Mechanics of Planar Assemblies

3-0-3. Prerequisite: Text. 7221.

A state-of-the-art study of woven, knit and nonwoven fabric mechanics.

Text. 7311. Polymer Degradation

3-0-3. Prerequisite: Text. 4750, 4751 or consent of school.

A study of the physical and chemical changes in polymeric materials exposed to hostile environments during processing and use.

Text. 7313. Dye Synthesis

3-0-3. Prerequisite: consent of school.

The industrial chemistry of dyes and their intermediates is covered. Structure is related to

color, fastness and affinity. Lapworth nomenclature and recent patents are surveyed.

Text. 7400. Information Processes in Textile Science and Engineering

3-0-3. Prerequisite: consent of school.

Informational aspects of textile science and technology; use of computers in acquisition, processing and utilization of information and knowledge in textile research and production.

Text. 7750. Surface and Solution Properties of Polymers

3-0-3. Prerequisite: consent of school.

Study of plasticized polymers, solutions and colloids; sorption, polymer characterization, interfacial phenomena and coagulation using thermodynamics, statistical mechanics, information and fluctuation theories and relaxation methods. Also taught as Ch.E. 7750.

Text. 7751. Energetics

3-0-3. Prerequisite: consent of school.

Energetics applied to polymers and fibers using Newtonian mechanics, thermodynamics, statistical thermodynamics and quantum mechanics to relate macroscopic and molecular descriptions of processes and materials.

Text. 7752. Kinetics

3-0-3. Prerequisite: consent of school

Kinetics applied to polymers and fibers including fluid flow, viscoelasticity, heat transfer, diffusion, electrical conductivity, rates of chemical reactions and phase changes and irreversible thermodynamics.

Text. 7753. Polymer Flow

3-0-3. Prerequisite: Text. or Ch.E. 6750 or consent of school.

The fluid mechanics, heat transfer and mixing of non-Newtonian fluids. Experimental methods for characterizing fluids and the extrusion of polymer melts are emphasized. Also taught as Ch.E. 7753.

Text. 7999. Preparation for Doctoral Qualifying Exams

Text. 8000-1-2. Seminar

1-0-0 each.

Text. 8100-1-2. Special Topics in Textile Science and Engineering

3-0-3 each. Prerequisite: consent of school.

Topics of current interest in textile science and engineering.

Text. 8500-1-2. Special Problems in Textiles and Textile Engineering

Credit to be arranged.

Text. 9000. Doctoral Thesis

RULES AND REGULATIONS

STUDENT RULES AND REGULATIONS

The Committee of Student Rules and Regulations: Sara Jackson, chairperson, E. Jo Baker, Frank Beckum, Milton Blood, Joseph L. Pentecost, William E. Woolf and three students.

Originally approved by the faculty May 24, 1949. Revised printings: 1952, 1957, 1960, 1965, 1968, 1971, 1973. Revised annually since 1973.

I. Purpose

These regulations are intended to set forth the requirements of the faculty to the end that a large student body may live and work together harmoniously with a minimum of friction and misunderstanding. Each student is expected to be a law-abiding citizen and to obey the laws of the City of Atlanta, Fulton County, the State of Georgia and the United States.

II. Responsibility for Notices and Change of Address

A. Notices

All students will be required to have a box in the post office of the Georgia Institute of Technology which will be their official address, and they are expected to check this box each school day. Students are also expected to be aware of the contents of the general notices which appear in the *Technique*.

B. Change of Address

Students are responsible for reporting changes of residential address, within one week's time, to the Office of the Registrar.

III. Attendance

A. General

1. Each quarter a course listing is published showing the time period for each class. Classes begin five minutes after the published starting time.
2. If an instructor should be late in meeting the class, the students shall wait twenty minutes after the published starting time. If the instructor has not arrived by that time, the students may leave unless specifically notified to await the instructor's arrival.

B. Class Attendance

1. There are no formal institutional regulations regarding class attendance at the Georgia Institute of Technology. The resources of the Institute are provided for the intellectual growth and development of the students who attend. A schedule of courses is provided for the students and faculty to facilitate an orderly arrangement of the program of instruction. The fact that classes are scheduled is evidence that attendance is important; students should, therefore, maintain regular attendance if they are to attain maximum success in the pursuit of their studies.
2. All students are responsible for obtaining an understanding of each instructor's policy regarding absences; all students are expected to attend announced quizzes, laboratory periods, and final examinations. Although it is recognized that occasionally it may be necessary for students to be absent from scheduled classes or laboratories for personal reasons, students are responsible for all material covered in their absences, and they are responsible for the academic consequences of their absences. Work missed may be made up if the rea-

sons for absences are acceptable to the instructors.

3. Students who are absent because of participation in approved Institute activities (such as field trips and athletic events) will be permitted to make up the work missed during their absences. Approval of such activities will be granted by the Student Academic and Financial Affairs Committee of the Academic Senate, and statements of the approved absences may be obtained from the Office of the Registrar.

IV. Grades and Scholastic Average

A. Grades

1. The letter grades for completed courses used in the calculation of scholastic average are the following:

A—excellent (four quality points);
B—good (three quality points);
C—satisfactory (two quality points);
D—passing (one quality point);
F—failure, must be repeated if in a required course (no quality points).

2. The following grades will be used in the cases indicated and will not be included in the calculation of scholastic average:

S—passing of a course taken under pass-fail or completion of a course in which no letter grade may be assigned;

U—failure of a course taken under pass-fail or unsatisfactory performance in a course for which no letter grade may be assigned;

V—assigned when the course has been audited; no credit given; implies no academic achievement on the part of the student and cannot serve as the basis for credit by examination at any future date.

3. The following grades will be used in the cases indicated:

I—incomplete. Assigned when a student is incomplete in some part of the course for reasons deemed satisfactory by the instructor, or is absent from the final examination for reasons deemed satisfactory by the instructor. If the student's record is so poor as to preclude his passing, the

instructor shall assign the grade of F or U. (Note: registering and repeating a course in which an "I" grade has previously been assigned *will not* remove the outstanding "I" grade.)

W—out before the end of the fifth week.

This symbol indicates that a student was permitted to withdraw without penalty. Withdrawals without penalty will not be permitted after the fifth week except in cases of hardship as determined by the registrar. Students who withdraw from school and receive all grades of W will not ordinarily be permitted to reenroll the next succeeding quarter.

4. Final grades are reported to the registrar at the end of each term.

5. If a final course grade is believed to be in error, the student should contact the professor as soon as possible. In general, no change of grade will be made after the end of the student's next quarter in residence.

B. Scholastic Average

The scholastic average is calculated as the ratio of the total number of quality points earned to the total number of quarter credit hours in which a final letter grade has been assigned.

V. Scholastic Regulations

A. Classification of Students

1. Undergraduate students with the exception of non-degree seeking students shall be classified at the end of each quarter by the Office of the Registrar on the basis of the total number of quarter credit hours for which they have credit in accordance with the following schedule:

freshman	0-45	credit hours
sophomore	46-90	credit hours
junior	91-136	credit hours
senior	137-	graduation

Students who have completed all requirements for a particular classification as defined by their major department may petition for reclassification through their major department.

2. Students scheduled for 12 credit hours or more are classified as fulltime students.

B. Eligibility for Class Rings

A student may purchase a class ring any-

time after receiving credit for 106 quarter credit hours.

C. Scholastic Standing

1. The minimum satisfactory scholastic average is 1.7 for freshmen, 1.9 for sophomores, 2.0 for juniors and seniors, and 2.7 for graduate students.

2. Good academic standing

a. Students not on academic warning or probation are in good academic standing.

b. Undergraduate students in good academic standing may schedule up to 23 credit hours with the approval of their school.

c. Graduate students in good academic standing may schedule up to 18 credit hours with the approval of their school.

3. Academic warning

a. A student who has an overall scholastic average below the minimum satisfactory scholarship requirement, or whose scholastic average for work taken during any quarter is below this requirement, shall be placed on academic warning.

b. An undergraduate student on academic warning shall be limited to a maximum schedule load of 16 credit hours.

4. Academic probation

a. A student on academic warning whose scholastic average is below the minimum satisfactory scholarship requirement for any quarter shall be placed on academic probation. Also see 6.b and 6.c opposite.

b. An undergraduate student on academic probation shall be limited to a maximum load of 14 credit hours.

5. Dean's List

The Institute encourages excellence in scholarship and gives official recognition to undergraduate students whose work is superior by publishing the Dean's List at the end of each academic quarter. The Dean's List includes all undergraduates who have, during the preceding quarter, made an academic average of 3.0 or higher, carried a load of at least 12 hours of course work on a credit basis, and are not on academic warning or probation or subject to any disciplinary action.

6. Dismissal for unsatisfactory scholarship

a. The Institute may drop from the rolls

at any time a student whose record in scholarship is unsatisfactory.

b. An undergraduate student whose scholastic average for any quarter is 1.0 or below may be referred to the Undergraduate Curriculum Committee, which may place the student on academic probation or drop, regardless of the student's previous record, if such action is deemed advisable.

c. A graduate student whose scholastic average for any quarter is 2.0 or below may be placed on academic probation or drop, regardless of the student's previous record.

d. A student on academic probation whose scholastic average for the quarter of probation is below the minimum satisfactory scholarship requirement and whose overall scholastic average is below the minimum satisfactory scholarship requirement shall be dropped for unsatisfactory scholarship and dropped from the rolls.

e. The record of a student on academic probation whose overall scholastic record is satisfactory but whose quarter average is unsatisfactory may be reviewed by the Undergraduate Curriculum Committee or the Graduate Committee, as appropriate. The student may be dropped or may be continued on academic probation.

7. Academic review

A student who normally would be dropped from the rolls for academic deficiencies but appears from the record not to have completed the quarter may be placed on academic review. This is a temporary standing which makes the student ineligible for registration. If no acceptable explanation is given within a reasonable time, the standing is changed to drop.

8. The scholastic standing regulations given above for graduate students do not preclude a school from having more rigorous requirements.

9. Part-time students

a. These regulations do not necessarily apply to students scheduling less than 12 credit hours.

b. The scholastic standing of these students may be determined by either the Undergraduate Curriculum Committee or the Graduate Committee, as appropriate, with

the decision based on individual merit in each case.

D. Change of Major

1. Undergraduate students, by filing the required form, will be permitted free transfer, as space permits, between schools during their first quarter at Georgia Tech. Thereafter, by filing the required form, free transfer will be permitted if the student is in good academic standing and not subject to disciplinary action and if space is available. Students not entitled to free transfer may transfer at the discretion of the school they wish to enter.

2. Graduate students, by filing the required form, may transfer with the concurrence of the schools involved.

E. Exceptions

Exceptions to these scholastic regulations may be made by the Undergraduate Curriculum Committee or the Graduate Committee, as appropriate, whenever a consideration of the student's complete record indicates that the application of a specific regulation will result in injustice.

VI. Deficiencies

A. General

1. A student who has received a grade of "I," "F," or "U" in a course has a deficiency in the course.

2. A student whose final grade is "F" or "U" has a failure in that course. He must repeat and pass the course in class before credit will be allowed. (See B.4).

B. Removal of Deficiencies

1. An incomplete in a course must be removed and the grade change reported to the Registrar not later than the end of the student's next quarter of residence.

2. The grade of "I" will not be counted in the computation of the student's point average at the end of the quarter in which the grade is received, nor in any quarter immediately following in which the student is not enrolled. If the "I" is not removed and the change of grade reported by the end of the student's next quarter in residence, the grade of "I" will be changed to an "F" on the student's permanent record and will count thereafter as an "F" in the computation of

point average. (Note: registering and repeating a course in which an "I" grade has previously been assigned *will not* remove the outstanding "I" grade.)

3. A student who has a failure in a required course must schedule that course the next time it is offered while the student is in residence.

4. A degree candidate who has a single course deficiency for graduation will be permitted one reexamination not later than 72 hours before commencement exercises and thereafter one examination per annum until the deficiency is removed, with the dates of the annual periods beginning 30 calendar days after the commencement exercises. This reexamination must be authorized by the Registrar before being scheduled. The examination will be graded "S" or "U" and grade so recorded. The previously assigned "F" or "U" will remain a part of the record.

5. A degree candidate who has otherwise completed all requirements for graduation and who has an incomplete in laboratory work taken during his final quarter in residence may remove the incomplete at the convenience of the department of instruction concerned.

VII. Withdrawal From School

A. General

1. A student 18 years of age or older may withdraw from school at any time upon the submission of a formal resignation.

2. A student under 18 years of age must include written permission from parents or guardian along with a formal resignation in order to withdraw from school before the official close of a quarter.

3. The proper forms for withdrawal are available from the Office of the Registrar. Students who withdraw without proper notification will receive grades of "F," "U," or "I" for the courses in which they were registered that quarter.

4. Permission and/or formal resignation are not required when a student has completed an official school quarter and does not register for the succeeding quarter.

5. See Section IV.A.3 for further information on withdrawal.

B. Readmission

See Section VIII for the regulations concerning readmission.

VIII. Readmission

A. General

1. A student who for any reason has remained out of school one or more quarters excluding the summer quarter must apply for readmission. This application, with all pertinent supporting information (except possibly another college transcript—see 2 below), must be submitted to the Registrar before the deadline for the quarter for which readmission is requested, as listed below:

Fall—August 1 Spring—March 1
Winter—December 1 Summer—June 1

Applications received after these deadlines will not be accepted.

2. Students who have attended other colleges should plan their readmission so as to allow ample time for official transcripts from those colleges to be sent to the Georgia Institute of Technology. If official transcripts have not been received prior to the last day of registration, the student seeking readmission will not be allowed to complete registration.

B. Readmission

1. A student who has been dropped once for unsatisfactory scholarship will ordinarily not be readmitted. A student who seeks an exception to this rule must have been out of the Institute for at least one quarter of the academic year and have had a conference with the major school concerning the readmission prior to the appropriate date listed in VIII.A.1 above. Because the summer quarter is not included in the academic year, students who are dropped at the end of the spring quarter will not be eligible for readmission until the beginning of the following winter quarter.

2. A student who is dropped a second time for unsatisfactory scholarship will not be readmitted to the Institute.

C. Transfer Credit

1. Course work pursued at another institution after dismissal from Georgia Tech for unsatisfactory scholarship may be considered as evidence for readmission.

2. If readmitted, a student will not necessarily be given transfer credit for work taken at another institution after dismissal from Georgia Tech.

3. In no case will credit be allowed (except by examination) for courses completed at another institution that have previously been failed at Georgia Tech.

IX. Scheduling

A. General

1. Each student is strongly advised each quarter to schedule all prerequisite courses possible, and should schedule all back courses before scheduling any advanced courses.

2. In dropping courses from their schedule, students must retain back courses in preference to advanced courses, unless permission to do otherwise is obtained from their school director.

3. The scheduling of back courses is the responsibility of the students, and they will be held accountable therefore.

4. Subject to approval by a faculty adviser, a course may be taken more than once for academic credit. All grades will count in determining the scholastic average, but the course will be counted only once for credit toward a degree.

5. See Sec. X for Institute rules for courses taken on a pass-fail basis.

B. Academic Load

1. The normal load scheduled by an undergraduate student in good standing should not exceed 21 credit hours. However, in exceptional cases, a total of 23 credit hours may be scheduled with the approval of the school.

2. Maximum credit hour loads are given in Sec. V.C.2, C.3 and C.4. Any hours above these limits must have prior approval of the Undergraduate Curriculum Committee or the Graduate Committee, as appropriate.

3. Graduate students must maintain a minimum of three credit hours each quarter of enrollment.

C. Auditing of Courses

1. Auditing of courses will be permitted to regularly enrolled students who have obtained the approval of their adviser and the departments concerned. Such courses

count at full value in computing the student's load.

2. The grade for auditing is "V" (visitor), and this grade will have no effect on the student's grade point average.

3. No academic credit is granted for audit participation in a course.

4. Students are not permitted to change to and from an auditing status except through the regular procedures for schedule change or withdrawal.

X. Pass-Fail System

A. General

1. At the option of the student's major school, credit toward a bachelor's degree may be allowed for courses taken under the pass-fail system and completed with a grade of "pass."

2. The major school must approve all pass-fail courses included in the final program of study, and students should become aware of school requirements.

3. In a graduate program, thesis research hours will be evaluated on a pass-fail basis.

4. Pass-fail enrollment in any course may be restricted by the school or department offering the course.

5. Students who are permitted to register under the pass-fail system will be so designated on the official class rolls; and the grades recorded will be "S," for pass, or "U," for failure. These grades will not be included in the calculation of the grade point average and cannot be changed to a grade which will count in the average.

6. Withdrawals from courses taken on a pass-fail basis will follow the same rules which govern withdrawals from courses included in the scholastic average.

B. Credit hours permitted

1. The maximum number of pass-fail hours permitted in an undergraduate program of study depends upon the number of credit hours that will be completed at Georgia Tech, as follows:

Credit Hours at Georgia Tech	Maximum Credit Hours Permitted on Pass-Fail Basis
50–89	3

90–134	6
135–179	9
180—or more	12

2. For a second undergraduate degree, these limitations apply to the credit hours approved for the program of study for that second degree.

3. A master's degree program of study may include up to six course credit hours on a pass-fail basis.

XI. Joint Enrollment at Georgia State University

A. General

1. With the approval of the student's major school, a student may schedule courses at Georgia State University if such courses are not available at Georgia Tech.

2. All registration activities are performed at Georgia Tech.

3. Withdrawals from Georgia State University courses will be performed at Georgia Tech, based on usual withdrawal regulations and procedures, with the exception that there will be no refund of fees.

4. Further information is available from the Office of the Registrar.

B. Eligibility

1. Joint enrollment is available only to degree-seeking juniors, seniors and graduate students.

2. To participate in joint enrollment, a student must be in good academic standing during the quarter when the application is processed and during the quarter of joint enrollment.

XII. Examinations

A. General

1. All reexaminations, examinations for advanced standing, and special examinations must be authorized by the Registrar before being scheduled.

2. If the instructor considers it necessary during an examination, students may be required to present their student identification card to the instructor or an authorized representative.

B. Examinations for advanced standing

1. Students who offer satisfactory evidence that they are qualified to do so may

receive credit for a course by examination. Such an examination is called an examination for advanced standing.

2. Examinations for advanced standing require the recommendation of the department of instruction in which the course is offered, payment of the appropriate fee and authorization by the Registrar.

3. Examinations for advanced standing will ordinarily be offered during the week of final examinations.

4. A student will not be allowed to take an examination for advanced standing in a given course more than twice.

5. An examination for advanced standing will be reported with an "S" or "U" grade. Neither grade will be included in the calculation of the scholastic average.

C. Final examinations for degree candidates

A degree candidate will be exempted from examinations during final examination week in the quarter of graduation.

D. Regulations covering final examinations

A student reporting to a final examination room more than 15 minutes after the scheduled starting time shall not be allowed to take the examination unless a satisfactory explanation is presented to the instructor conducting the examination.

XIII. Undergraduate Degrees

A. General

1. To be considered for admission to candidacy for a degree, a student must have passed the Regents' Test and must make a formal petition for the degree during the quarter preceding the final quarter in residence. A petition for degree will not be accepted until the Regents' Test has been passed.

2. Students desiring to withdraw their name from the rolls of degree candidates, must formally withdraw the petition for degree before the end of the eighth week of the quarter.

3. A degree program may include a maximum of six hours of basic ROTC and a maximum of nine hours of advanced ROTC.

4. The diploma of a candidate for a degree

shall bear the date of the commencement at which the degree is awarded.

5. No student may be considered a candidate for a degree unless the final 50 credit hours required for the degree are earned in residence at Georgia Tech.

6. Work which was completed more than 10 years prior to commencement must be validated by special examinations before it can be counted toward a degree.

B. Requirements for a degree

1. To be a candidate for a degree, undergraduate students must have passed all courses required for the degree, must have a scholastic average for his entire academic program of at least 2.0, and must have done creditable work in their departmental courses so as to merit the recommendation for the degree by the director and faculty of their school.

2. Students, with the approval of their school or specialization, may satisfy the requirements for an undergraduate degree by meeting all of the requirements listed in any one of the catalogs in effect during the period of their enrollment in the Institute. A catalog is in effect for a student only if the student's date of matriculation is prior to the ending date of the spring quarter shown in the calendar printed in the catalog concerned.

3. Constitution and history examinations

a. The Georgia law as amended March 4, 1953, requires that before graduation all students pass examinations or pass comparable courses in United States and Georgia history as well as United States and Georgia Constitution.

b. Courses which may be substituted for the United States and Georgia Constitution and history examinations are listed in this catalog in the section for the Department of Social Sciences.

4. Regents' testing program

All students completing requirements for baccalaureate degrees are required by the University System of Georgia to pass an examination designed to measure proficiency in reading and English composition. This examination, known as the Regents' Test, is to be taken before the end of the sophomore year. If failed, it must be repeated quarterly until passed. It must be

passed before a petition for graduation will be accepted. Students should obtain further information from the registrar.

5. Major area examination

All students completing requirements for baccalaureate degrees are required by the University System of Georgia to take a major area examination prior to being certified as having completed all requirements for the degree.

6. Physical education requirement

a. Unless medically disqualified, all students are required to complete the swimming course P.E. 1010 before graduation.

b. See Sec. XV for a complete description of the physical education requirements at Georgia Tech.

C. Graduation with academic distinction

1. For graduation with highest honor the minimum scholastic average shall be 3.6.

For graduation with high honor the minimum scholastic average shall be 3.4. For graduation with honor the minimum scholastic average shall be 3.2.

2. A student must have earned at least 100 credit hours at Georgia Tech to graduate with highest honor, with high honor or with honor.

D. Second undergraduate degree

1. A student enrolled for a second undergraduate degree shall be classified an undergraduate student.

2. To be a candidate for a second undergraduate degree, a student must have the recommendation of the director of the school concerned and the approval of the Undergraduate Curriculum Committee.

3. To obtain a second undergraduate degree, a student must complete all major required courses for the degree and earn credit for a total of at least 50 credit hours in excess of the requirement for any previous degrees earned.

4. All regulations in Sections XIII A, B, and C apply to students completing second degrees.

XIV. Graduate Degrees

A complete description of Institute requirements for the master's and doctor's degrees is given in this catalog in the section

entitled "Information for Graduate Students." Also see Section XIII.A.2 for a regulation concerning withdrawal of a petition for degree.

XV. Physical Education

A. General

1. All students entering Georgia Tech as freshmen are required to satisfactorily complete three credit hours in physical education courses. Unless medically disqualified, all students will be required to complete swimming (P.E. 1010) plus two additional courses. One of these must be selected from the remaining courses at the 1000 level, and one must be selected from the 2000 level.

2. Transfer students will be granted credit for comparable physical education courses completed at other institutions.

3. Students who are 25 years of age or older upon matriculation to the Institute have the option of satisfying the physical education requirement for graduation by completing the regular physical education requirements or by completing P.E. 1040.

B. Medical Exemptions

1. The Health Information Record on file with the Director of Health will be used to determine any medical exemptions from physical education courses. All certificates of disability from personal physicians must be endorsed by the Student Health Services before they will be accepted by the Department of Physical Education and Recreation.

2. Students who are medically exempt from swimming must substitute another 1000 level activity course in its place, if possible.

3. Students who are medically exempt from all 1000 level activity courses may complete their requirement either with 2000 level courses, if possible, or with P.E. 1040.

4. Students who are medically exempt from all physical education activity courses will be required to complete P.E. 1040 to satisfy their physical education requirement.

XVI. Student Motor Vehicles

Students desiring to operate motor vehicles on campus are subject to all rules set forth by the Georgia Tech motor vehicle regulations.

XVII. Medical Regulations

A. General

1. No student with a contagious disease may stay in a dormitory or fraternity house or attend class. Any illness with fever should be considered a contagious disease until checked by a physician. Every student is held individually responsible for reporting such illness immediately to the infirmary.

2. A current Health Information Record and a consent-for-treatment form must be on file with the Director of Health.

B. Infirmary Regulations

Students must conform to infirmary regulations, as posted in the infirmary, while confined as patients in the infirmary.

XVIII. Extracurricular Activities

A. Participation

1. In order to be eligible for participation in extracurricular activities, a student must satisfy the following requirements:

- a. be enrolled in a degree program;
- b. maintain a schedule with at least six credit hours on a credit basis, or be a student in the Cooperative Division on work quarter;
- c. not on academic or disciplinary probation.

2. Participation also requires satisfaction of any additional requirements established by the Student Activities Committee of the Academic Senate.

B. Scheduling of events

1. During the first week of each quarter, a schedule of public performances to be sponsored by each student organization must be submitted to the Dean of Students for approval by the Student Academic and Financial Affairs Committee of the Academic Senate.

2. All student organizations must make written application to, and receive permission from, the Dean of Students to hold a social function. The request must be sub-

mitted at least one week before the date of the activity, and the permission must be received before making any agreements in connection with the function.

3. In each quarter, the weekend before final examinations is closed to student sponsored extracurricular events.

C. Student organizations

Requirements and standards for chartering a student organization are established by the Student Activities Committee of the Academic Senate and are available from the Dean of Students.

D. Fraternity and Sorority regulations

1. To be eligible for initiation, a student must be a full-time student not on academic or disciplinary probation.
2. The initiation of any individual must be registered with and approved by the Dean of Students prior to the initiation.
3. The individual must meet all Georgia Tech I.F.C. requirements concerning initiation.
4. All fraternities and sororities are subject to the rules established by the Georgia Tech I.F.C.

5. All fraternities and sororities are subject to the rules established by the Georgia Tech I.F.C.

E. Intercollegiate athletic regulations

1. To be eligible for intercollegiate athletic competition, a student must be enrolled in a degree program, carrying a workload of at least 12 credit hours, and not on academic or disciplinary probation. In addition, he must be making satisfactory progress towards a degree and meet any further requirements of the NCAA or other governing organization; see the athletic director for details.
2. No student may be excused from regularly scheduled classes for athletic practice.
3. No student may participate in more than two sports in intercollegiate competition in any school year, except by permission of the Dean of Students. Being manager or assistant manager is counted as participation within the meaning of this rule.

XIX. Student Conduct Code

A. General

A student enrolling in the Georgia Institute of Technology assumes an obligation to conduct himself in a manner compatible

with the Institute's function as an educational institution. Actions considered inimicable to the Institute and subject to discipline fall into the categories of academic and nonacademic misconduct.

B. Academic misconduct

Academic misconduct is any act which does or could improperly distort student grades or other student academic records. Such acts include but need not be limited to the following:

1. Possessing, using, or exchanging improperly acquired written or verbal information in the preparation of any essay, laboratory report, examination or other assignment included in an academic course;
2. Substitution for, or unauthorized collaboration with, a student in the commission of academic requirements;
3. Submission of material which is wholly or substantially identical to that created or published by another person or persons, without adequate credit notations indicating the authorship (plagiarism);
4. False claims of performance for work which has been submitted by the claimant;
5. Alteration or insertion of any academic grade or rating so as to obtain unearned academic credit;
6. Deliberate falsification of a written or verbal statement of a fact to a member of the faculty so as to obtain unearned academic credit;
7. Forgery, alteration, or misuse of any Institute document relating to the academic status of the student.

C. Nonacademic misconduct

Nonacademic misconduct includes the following specifically prohibited acts whenever, unless otherwise stated, such acts occur on Institute owned or controlled property or Institute related premises:

1. Alcohol abuse, including:
 - a. Conspicuous or flagrant possession of alcoholic beverage;
 - b. Intoxication made manifest by boisterousness, rowdiness, obscene or indecent conduct or appearance, or vulgar, profane, lewd, or unbecoming language;
 - c. Disorderly conduct associated with the use of alcoholic beverages;
2. Pushing, unjustifiably striking or physically assaulting, or otherwise intentionally

threatening or endangering the person of any member of the faculty, administration, staff or student body or any visitor to the campus;

3. Disorderly conduct, including:

- a. Breach of the peace or obstruction or disruption of teaching, research, administration, disciplinary procedures or other Institute activities, including its public service functions or other authorized activities;
- b. Refusal to vacate a building, street, sidewalk, driveway or other facility when directed to do so by any properly identified Institute faculty, administration or staff personnel while these persons are acting in the performance of their duties;
- c. Lewd, indecent or obscene conduct or expression;
- d. Failure to comply with instructions or directions of any properly identified faculty, administration or staff personnel while these persons are acting in the performance of their duties;
4. Drug abuse, including the use or possession (without valid medical or dental prescriptions), manufacture, furnishing, sale, or any distribution of any narcotic or dangerous drug controlled by law; this provision is not intended to regulate alcoholic beverages, which are covered in section 1 above.
5. Unauthorized use of college facilities, including:
 - a. Unauthorized entry into any Institute building, office, or other facility, or remaining in any building after normal closing hours;
 - b. Unauthorized use of any Institute telephone facility or of any other Institute facilities;
 - c. Possessing, using, making, or causing to be made any key for any Institute facility without proper authorization;
 - d. Unauthorized use of another student or faculty member's password to gain access to the computer or computer output. This includes but is not limited to any knowing and willing use of fraudulent means to process computer programs and access computer files.
6. Furnishing false information to any Institute official, or offering false statement in any Institute disciplinary hearing.

7. Forgery, alteration or misuse of any Institute document, record or identification.
8. Any hazing action which tends to cause or allow physical or mental suffering in connection with rites or ceremonies of induction, initiation or orientation into Institute life or into the life of any Institute group or organization.
9. Safety violations, including:
 - a. Intentional false reporting of a fire or that any explosive device has been placed on Institute property;
 - b. Tampering with fire-fighting equipment, safety devices or other emergency or safety equipment;
 - c. Setting an unauthorized fire;
 - d. Possession of unauthorized fireworks, firearms, ammunition or dangerous weapons or materials;
 - e. Unauthorized sale, possession, furnishing or use of any incendiary device or bomb;
 - f. Use of smoking tobacco, in any form, in facilities or areas posted with "No Smoking" signs, or where smoking has been prohibited by any faculty member or other official.
10. Theft and/or unauthorized possession of Institute property or property of a member of the Institute community or campus visitor.
11. Malicious or unauthorized damage or destruction to Institute property or property belonging to any member of the Institute community or campus visitor.
12. Violation of rules governing residence in Institute owned or controlled property such as dormitories, family housing, fraternities, and organization housing.
13. Playing of games of skill or chance for money or other items of value.
14. Failure to remit, return, or submit financial obligations, property or records of the Institute, within the time prescribed by the Institute.
15. Knowingly acting in concert with any other person to perform an unlawful act or to violate an Institute regulation or policy.
16. Violations of the Georgia Tech Motor Vehicle Regulations.
17. Violation of the Regents' Statement on Disruptive Behavior, the full text of which is given in Section XX.

18. Repeated violations of the published rules and regulations of the Institute, which cumulatively indicate an unwillingness or inability to conform to the Institute standards for student life.

19. Violation of the conduct code, wherever it may occur, or violation of the laws of any city, county, state, or the United States, where the violation creates a clear and present danger of material interference with the normal or orderly processes of the Institute or its requirements of appropriate discipline.

XX. Regents' Statement on Disruptive Behavior

The following is the policy of the board of regents regarding disruptive behavior in any institution of the university system. The rights, responsibilities and prohibitions contained in this statement are incorporated as a part of these regulations.

The Board of Regents of the University System of Georgia reaffirms its policies to support fully, freedom of expression by each member of the academic community and to preserve and protect the rights and freedom of its faculty members and students to engage in debate, discussion, peaceful and nondisruptive protests and dissent. The following statement relates specifically to the problem described below. It does not change or in any way infringe upon the board's existing policies and practices in support of freedom of expression and action. Rather, it is considered necessary to combat the ultimate effect of irresponsible disruptive and obstructive actions by students and faculty which tend to destroy academic freedom and the institutional structures through which it operates.

In recent years a new and serious problem has appeared on many college and university campuses in the nation. Some students, faculty members and others have on occasion engaged in demonstrations, sit-ins and other activities that have clearly and deliberately interfered with the regular and orderly operation of the institution concerned. Typically, these actions have been the physical occupation of a building or campus area for a protracted period of time or the use or display of verbal or written

obscenities involving indecent or disorderly conduct.

These actions have gone beyond all heretofore recognized bounds of meetings for discussion, persuasion or even protest in that: (1) acquiescence to demands of the demonstrators is the condition for dispersal and (2) the reasonable and written directions of institutional officials to disperse have been ignored. Such activities thus have become clearly recognizable as an action of force, operating outside all established channels on the campus, including that of intellectual debate and persuasion which are at the very heart of education.

The board of regents is deeply concerned by this new problem. Under the Constitution of the state of Georgia, under all applicable court rulings and in keeping with the tradition of higher education in the United States, the board is ultimately responsible for the orderly operation of the several institutions of the university system and the preservation of academic freedom in these institutions. The board cannot and will not divest itself of this responsibility.

Of equal or even greater importance, such action of force as has been described above destroys the very essence of higher education. This essence is found in the unhampered freedom to study, investigate, write, speak and debate on any aspect or issue of life. This freedom, which reaches its full flowering on college and university campuses, is an essential part of American democracy, comparable to the jury system or the electoral process.

For these reasons and in order to respond directly and specifically to this new problem the board of regents stipulates that any student, faculty member, administrator or employee, acting individually or in concert with others, who clearly obstructs, disrupts or attempts to obstruct or disrupt any teaching, research, administrative, disciplinary, public service activity or any other activity authorized to be discharged or held on any campus of the University System of Georgia is considered by the board to have committed an act of gross irresponsibility and shall be subject to disciplinary procedures, possibly resulting in dismissal or termination of employment.

The board reaffirms its belief that all segments of the academic community are under a strong obligation and have a mutual responsibility to protect the campus community from disorderly, disruptive or obstructive actions which interfere with academic pursuits of teaching, learning and other campus activities.

The board of regents understands that this policy is consistent with resolutions adopted by the American Association of University Professors in April 1968, by the Association of American Colleges in January 1968 and by the executive committee of the Association for Higher Education in March 1968 condemning actions taken to disrupt the operations of institutions of higher education.

XXI. Disciplinary Administration

A. Disciplinary procedures

1. All acts of misconduct (excepting violations of motor vehicle regulations) on the part of students shall be reported to the Dean of Students, who is designated the principal administrator to enforce Institute disciplinary measures as they pertain to student academic or nonacademic misconduct.

2. The Dean of Students shall investigate alleged acts of student misconduct. If the investigation indicates that further action is necessary, the Dean of Students shall notify the accused in writing. This written notification shall contain a statement of the nature of the alleged or suspected misconduct, and state the sections of the conduct code the student is alleged to have violated.

3. The Dean of Students or the dean's authorized representative will normally confer with the accused student, and at this conference the student may admit or deny the alleged violation, the student may waive further hearing and appeal(s) in writing and request that the Dean of Students take appropriate action, or may request a hearing as specified in 4, 5, or 6 below.

4. Cases of academic misconduct will normally be referred to the Student Honor Committee, which shall hear and try cases involving academic misconduct on the part of any student.

5. Cases of serious nonacademic misconduct which may result in suspension or expulsion will normally be referred to the Graduate Judiciary or Undergraduate Judiciary Cabinet, which shall hear and try these cases. This does not preclude possible legal actions by appropriate law enforcement agencies in those cases of nonacademic misconduct in violation of federal, state or local law.

6. If the case does not involve possible suspension or expulsion, the Dean of Students ordinarily shall make full disposition of the case except that the dean shall at the request of the accused, or for good cause may, refer any case of nonacademic misconduct to the Graduate Judiciary or Undergraduate Judiciary Cabinet.

7. Students accused of an act of academic misconduct or nonacademic misconduct are encouraged to notify their parents or guardian of the charges. Parents or guardian will, if requested, be granted a conference with the Dean of Students prior to the hearing.

8. An accused student will continue to attend classes and required Institute functions until the hearing is held and a decision is rendered. Exceptions to this will be made when the student's presence may create a clear and present danger of materially interfering with the Institute's normal operations or the requirements of appropriate Institute discipline. In such cases, the Dean of Students may impose temporary protective measures, including interim suspension, pending the hearing; such protective measure, if applied, will be without reasonably avoidable prejudice to the student.

B. Student Honor Committee

1. The Student Honor Committee shall consist of four members of the corps of instruction elected from the Academic Senate and two undergraduate students with at least junior standing elected by the Student Council and one graduate student elected by the Graduate Student Senate. Student members must have good academic standing and must not be on disciplinary probation. The chairman shall be elected annually by the committee from among the

Academic Senate members. The secretary shall be appointed by the chairman.

2. The committee shall hear and try all cases referred to it involving alleged dishonesty in academic matters on the part of students. The decision in the case shall be transmitted to the office, or offices, responsible for recording it, for notifying the student officially and for implementing the action.

3. In its distributed minutes and in the annual report of its activities and findings, the committee shall preserve the anonymity of individuals by generalizing the issues involved and the actions taken.

C. Student judiciary

1. The Graduate Judiciary shall consist of a graduate student chairman and six graduate student justices. The graduate student justices and chairman shall be currently enrolled, full-time graduate students in good academic standing and not on disciplinary probation. They are appointed by the graduate student body president and approved by the Graduate Student Senate. The Graduate Judiciary shall normally hear all cases of graduate student nonacademic misconduct in which there is the possibility of suspension or expulsion of the accused student.

2. The Undergraduate Judiciary Cabinet shall consist of an undergraduate student chairman and 10 undergraduate student justices. The undergraduate student justices and chairman will be currently enrolled, full-time, undergraduate students in good academic standing and not on disciplinary probation. They are appointed by the student body president and approved by the Student Council. The Undergraduate Judiciary Cabinet shall normally hear all cases of undergraduate student nonacademic misconduct in which there is a possibility of suspension or expulsion of the accused student.

D. Procedural rights of the accused

Students accused of an act of misconduct and summoned to a hearing before the Student Honor Committee, Graduate Judiciary, or Undergraduate Judiciary Cabinet have the right to:

1. Be accompanied by an adviser of their choice;

2. Remain silent with no inference of guilt drawn therefrom;

3. Question the complainant;

4. Present evidence in their behalf;

5. Call pertinent witnesses in their behalf;

6. Cross-examine witnesses;

7. In Undergraduate Judiciary Cabinet hearings the accused may challenge and unseat as many as four student justices (the chairman cannot be struck; a quorum of six student justices and the chairman must remain);

8. Appeal.

E. Hearing procedures

1. The chairman of the appropriate hearing body shall set the date, time and place of the hearing, shall notify the members of the hearing body, and summon all principals in the case (defendants and witnesses).

2. The chairman of the appropriate hearing body shall notify the accused student in writing at least three days in advance of the scheduled hearing. The written notification should, if reasonably possible, be hand-delivered; if not reasonably possible, notification should be by registered mail to the student's local address. The written notification should specify:

a. The date, time and place for the hearing;

b. A statement of the nature of the alleged or suspected misconduct with which the student is accused, with sufficient particularity to ensure opportunity to prepare for the hearing;

c. Names of witnesses scheduled to appear.

3. Decisions of the hearing body shall be by majority vote. A quorum for the Student Honor Committee shall consist of five members, three faculty members and two students. A quorum for the Undergraduate Judiciary Cabinet shall consist of the chairman and six justices. A quorum for the Graduate Judiciary shall consist of the chairman and four justices.

4. Members of the hearing body shall disqualify themselves if their personal involvement in the hearing is of such a nature as to prejudice the case.

5. The hearings of the Student Honor Committee, Graduate Judiciary and Under-

graduate Judiciary Cabinet shall ordinarily be closed except for the accused, the accused's adviser and those directly involved; exceptions may be made at the discretion of the chairman. The hearing body may exclude any person who may be reasonably expected to interfere materially with the hearing or who does interfere materially with the hearing. Hearing body deliberations are closed to all but the hearing body members.

6. The hearing body shall make a tape recording and/or summary transcription of the proceedings.

7. The hearing body shall provide a brief written summary of each case with recommendations for appropriate disciplinary action to the Dean of Students and to the student involved.

8. The Dean of Students will review the case and recommendations and implement disciplinary action.

F. Disciplinary measures

For violations of Institute rules and regulations or for acts of student misconduct, academic or nonacademic, the following disciplinary measures may be taken. This list is not exhaustive and may be modified to meet particular circumstances in any case.

1. Expulsion—permanent severance of the student's relationship with the Institute;

2. Disciplinary suspension—temporary severance of the student's relationship with the Institute for a specific period of time, though not less than one quarter;

A student expelled or suspended shall leave the campus and not visit the campus during the period of suspension or expulsion, except when on official school business. To violate this stipulation would affect adversely the student's chances for readmission.

3. Reprimand—an oral and/or written statement of disapproval issued to the student;

4. Restriction—exclusion from participation in social activities and loss of identification card privileges;

5. Disciplinary probation—notice to the student that any further major disciplinary violation may result in suspension or expulsion; may include setting of restrictions

and/or issuing a reprimand. A student on disciplinary probation is not in good standing and may not participate in extracurricular activities.

6. Fines;

7. Restitution—reimbursement for damage to or misappropriation of property; this may take the form of appropriate service or other compensation;

8. Forced withdrawal—withdrawal from the academic course within which the offense occurred without credit for the course;

9. Change in grade—grade change for the course in which the offense occurred.

G. Appeal procedures

1. If accused students or accusers are dissatisfied with the action taken by the Dean of Students, they may appeal the case in writing to the president of Georgia Tech within five days after the action about which there is a complaint. Such appeal shall recite all reasons for dissatisfaction with the previous decision.

2. The president, within five days, shall refer the appeal to the Student Grievance and Appeal Committee. This committee shall review all facts and circumstances connected with the case and shall within five days make its findings and report thereon to the president. After consideration of the committee's report, the president shall within five days make a decision which shall be final so far as the Institute is concerned.

3. The Student Grievance and Appeal Committee shall consist of three members of the corps of instruction elected from the Academic Senate and two students with at least junior standing elected jointly by the Student Council and the Graduate Senate. The chairman shall be elected annually by the committee from among the elected Academic Senate members. The secretary shall be appointed by the chairman.

4. The Board of Regents of the University System of Georgia is the final appellate authority for all cases involving students who have been suspended or expelled. Should aggrieved persons be dissatisfied with the decision of the president, they may apply to the board of regents, without prejudice to their position, for a review of the decision. The application for review shall be

submitted in writing to the executive secretary of the board within a period of 20 days following the decision of the president. This application for review shall state the decision complained of and the redress desired. A review of the board is not a matter of right, but is within the sound discretion of the board. If the application for review is granted, the board, or a committee of the board, shall investigate the matter thoroughly and render its decision thereon within 60 days from the filing date of the application for review or from the date of any hearing which may be held thereon. The decision of the board shall be final and binding for all purposes.

XXII. Exceptions

Where appeals are not otherwise specified, exceptions to these regulations may be made by the appropriate faculty committee upon petition by the student and recommendation of the student's school or department. Blanket exceptions which have the effect of amending these regulations shall be referred to the Academic Senate for approval.

ADMINISTRATION, FACULTY AND STAFF

ADMINISTRATION Board of Regents

The Georgia Institute of Technology is one of the educational institutions constituting the University System of Georgia. The university system is governed by a 15-member board of regents, the members of which are appointed to seven-year terms by the governor of Georgia. The members of the board of regents are listed below.

****Marie W. Dodd, Roswell**State-at-Large
Jesse Hill, Jr., AtlantaState-at-Large
Milton Jones, ColumbusState-at-Large
O. Torbitt Ivey, Jr.,
AugustaState-at-Large
Rufus B. Coody, ViennaState-at-Large
Erwin A. Friedman,
SavannahFirst District
William T. Divine, Jr.,
AlbanySecond District
John H. Robinson III,
AmericusThird District
Scott Candler, Jr., Decatur ..Fourth District
Elridge W. McMillan, AtlantaFifth District
***Lamar R. Plunkett,**
BowdonSixth District
Lloyd L. Summer, Jr.,
RomeSeventh District
Thomas H. Frier, Douglas ...Eighth District
Sidney O. Smith,
GainesvilleNinth District
Julius F. Bishop, AthensTenth District

*Chairman

**Vice Chairman

Chancellor of the University System and the Administrative Staff

Chancellor Vernon D. Crawford is the chief administrative officer of the university system and the chief executive officer of the board of regents. Members of his administrative staff are the following:

George A. Christenberry, acting vice-chancellor
Henry G. Neal, executive secretary
H. Dean Propst, vice-chancellor,
Academic Development
Frank C. Dunham, vice-chancellor,
Facilities
Shealy E. McCoy, vice-chancellor, Fiscal
Affairs
Harry B. O'Rear, vice-chancellor, Health
Affairs
Haskin R. Pounds, vice-chancellor,
Planning
Mario J. Goglia, vice-chancellor, Research
Howard Jordan, Jr., vice-chancellor,
Services

INSTITUTIONAL ADMINISTRATION

President

Joseph Mayo Pettit, Ph.D., *president*
Richard Fuller, Jr., Ph.D., *executive assistant to the president*

Academic Affairs

James R. Stevenson, Ph.D., *acting vice-president, Academic Affairs*
Walter L. Bloom, M.D., *associate vice-president, Academic Affairs*
E. Jo Baker, Ph.D., *associate vice-president, Academic Affairs*

Research

Thomas E. Stelson, D.Sc., *vice-president, Research (on leave)*
Albert P. Sheppard, Ph.D., *acting vice-president, Research*
Edward E. Renfro III, M.A., *director, Contract Administration*

Business and Finance

Gene M. Nordby, M.S., Ph.D., *vice-president, Business and Finance*
Frank H. Huff, B.B.A., C.P.A., *comptroller*
H. T. Marshall, A.B., LL.B., C.P.A., *director, Internal Auditing, Systems and Procedures*
C. Evan Crosby, B.S., *budget director*
Clyde D. Robbins, Ph.D., *director, Office of Campus Planning*
Charles R. Johnson, B.M.E., *director, Physical Plant*
Howard J. Fretwell, B.B.A., *director, Personnel*
Roger E. Wehrle, B.S., *director, Auxiliary Enterprises*
George Mitchell, B.A., *director, Bookstore*
Kathleen Stanwyck, *manager, Financial Data Processing*
John H. Gibson, M.B.A., *assistant to the vice-president, Employee Relations*
Edmund F. Berry, M.A., *chief, Campus Police*
Delores Gaddis, *acting director, Purchasing and Inventory Management*

Institute Relations and Development

Warren Heemann, M.A., *vice-president*
John P. Culver, M.A., *assistant vice-president*
John J. Kalamarides, A.B., *assistant vice-president*
Robert H. Rice, B.S., *executive director, Georgia Tech National Alumni Association*
Eleanor C. Cain, A.B., *Secretary, Georgia Tech Foundation, Inc., and assistant to the vice-president*
Michael A. Donahue, Ph.D., *director, Corporate Relations and Placement*
Charles E. Harmon, A.B., *director, New Bureau*
Susan Langford, B.A., *director, Alumni Programs, Georgia Tech National Alumni Association*
Mary G. Peeke, *director, Alumni Placement, Georgia Tech National Alumni Association*
Mary S. Retzer, M.P.A., *director, Accounting*
Barbara Rose, A.B.A., *director, Special Gifts*
Claude L. Saunders, Jr., B.S., *director, Estate Planning*
Dell Sikes, B.S., *director, Annual Giving, Georgia Tech National Alumni Association*
Jack Thompson, *director, Alexander-Tharpe Scholarship Fund, Inc.*
Thomas L. Vitale, B.F.A., *director, Publications*

Planning

Clyde D. Robbins, Ph.D., *vice-president, Planning*
Paul Weber, Ph.D., *special assistant to the vice-president for planning and vice-president for planning emeritus*
David O. Savini, B.Arch. *campus architect*
Paul vander Horst, B.L.A., *campus landscape architect*
Thomas R. Kirby, B.S., *facilities planner*
J. R. Anthony, *comptroller emeritus and special assistant to the vice-president for planning*

College of Architecture

William L. Fash, M.Arch., *dean*
Joseph N. Smith, B.Arch., *assistant dean for Instruction*
John A. Templer, Ph.D., *assistant dean for Research*

College of Engineering

William M. Sangster, Ph.D., *dean*
W. Denney Freeston, Ph.D., *associate dean*
Carolyn C. Chesnutt, M.S., *assistant to the dean*
Coleen A. Donahue, M.S., *assistant to the dean*

College of Management

Charles E. Gearing, Ph.D., *dean*
Milton R. Blood, Ph.D., *associate dean*
Andrew J. Cooper III, Ph.D., *assistant dean/administration*
Marilu McCarty, Ph.D., *assistant dean/student affairs*

College of Sciences and Liberal Studies

H. S. Valk, Ph.D., *dean*
Patrick Kelly, Ph.D., *associate dean*
Virginia S. Watts, Ph.D., *assistant dean*
Joseph F. Jackson, M.S., *assistant to the dean*

Engineering Experiment Station

Donald J. Grace, Ph.D., *director*
H. G. Dean, B.S., *associate director*
James C. Wiltse, Jr., Ph.D., *associate director*
Rudolph L. Yobs, M.S., *associate director*

Cooperative Division

James Gordon Wohlford, M.S., *director*
William H. Hitch, B.M.E., *associate director*
Thomas M. Akins, M.B.A., *assistant director*
Robert W. James, B.S., *assistant director*

Registrar

Frank E. Roper, M.S.I.E., *registrar*
William F. Leslie, M.S., *associate registrar*
James L. Garner, M.S.I.M., *director, Registration and Records*
Jerry L. Hitt, M.Ed., *director, Admissions*
William T. Lee, B.S., *director, Financial Aid*

Dean of Students

James E. Dull, M.Ed., *dean of students*
Edwin P. Kohler, M.Ed., *associate dean of students*
Carole E. Moore, Ph.D., *assistant dean, women's activities*
W. Miller Templeton, M.S., *assistant dean and international student adviser*
Barry D. Birkhead, M.A., *assistant dean, fraternity adviser*
John A. Wilhelm, M.D., *director, Student Health Service*
James A. Strickland, Ed.D., *director, Student Counseling Center*
Gary J. Schwarzmuller, M.S., *director, Housing*
Roger E. Wehrle, B.S., *director, Student Center*
H. Keith Ivey, B.A., *director, New Student Orientation*

Institutional Research

Rocker T. Staton, Ph.D., *director*
Jennifer P. Martin, A.S., *assistant to the director*

Department of Industrial Education

Charles R. Vail, Ph.D., *coordinator*
Jerry L. Birchfield, M.S., *acting director*
Bobby R. Cline, B.B.A., *program specialist*
Charles A. Duke, B.S., *administrative specialist*
George D. Kearney, B.S., *program specialist*

Computing Services

C. P. Reed, Jr., M.S., *director, Computing Services*
Gary G. Watson, M.S., *associate director, Application System Design*
Jerry W. Head, B.S., *associate director, Application System Programming*
S. Paine Lenoir, M.S., *associate director, Computer Operations*
Frank Gleason, M.S., *assistant to the director*

Libraries

E. Graham Roberts, Ph.D., *director*
Helen R. Citron, M.A., *associate director, technical services*
Arthur T. Kittle, D.L.S., *associate director, public services*

Graduate Studies and Research

James J. Bynum, Ph.D., *acting dean, Graduate Studies*
Helen E. Grenga, Ph.D., *associate dean*

Department of Continuing Education

Charles R. Vail, Ph.D., *director*
Robert S. Herndon, M.Ed., *associate director*
George H. Adams, M.A., *associate director*
David M. Wolfson, B.A., *assistant director*

Georgia Tech Research Institute

Joseph M. Pettit, Ph.D., *president*
Thomas E. Stelson, D.Sc., *vice-president*
William H. Borchert, M.S., *vice-president and general manager*

Interdisciplinary Programs

Jack M. Spurlock, Ph.D., *director, Interdisciplinary Programs and director, Bioengineering Center*
Melvin W. Carter, Ph.D., *associate director, Interdisciplinary Programs and associate director, Bioengineering Center*
Bernd Kahn, Ph.D., *director, Environmental Resources Center*

Health Systems Research Center

Harold E. Smalley, Ph.D., *director*
Julian V. Pittman, B.S.Ed., *research planning coordinator*

Department of Campus Safety

Theodore Marvin, M.P.A., *director*
Ed Berry, M.Ed., *chief of police*

Radiological Safety

R. M. Boyd, B.S., *radiological safety officer*

Georgia Tech Athletic Association

Homer C. Rice, A.B., *athletic director and assistant to the president*
John O'Neill, B.S., *associate athletic director/business manager*
Jack Thompson, *assistant athletic director*
James K. Luck, B.S., *assistant athletic director*

Academic Faculty as of March 1, 1980

After each name the highest earned degree and its source is listed. The academic rank is followed by the individual's major assignment. Professional registration is indicated with the state(s) of registration as follows: P.E. = Professional Engineer, L.S. = Land Surveyor, R.A. = Registered Architect, L.A. = Landscape Architect, P.G. = Professional Geologist.

Barbara W. Aba-Mecha, Ph.D.
Emory University
Assistant Professor, English

Lawrence E. Abbey
Research Technician I,
Chemistry

Agaram S. Abhiraman, Ph.D.
North Carolina State University
Assistant Professor, Textile Engineering

Aristides F. Abril, D.C.S.
University of Havana
Professor, Management

Elaine S. Acree, M.S.
Georgia Institute of Technology
Research Scientist I, EES

Susan S. Adamovitz, B.S.
DePaul University
*Research Scientist I
Interdisciplinary Programs*

George H. Adams, M.A.
Georgia State University
Associate Director of Continuing Education

Joseph D. Adams, M.S.
Emory University
Senior Research Scientist, EES

Philip Adler, Jr., Ph.D.
Ohio State University
Professor, Management

Carol M. Agee, M.S.
Virginia Polytechnic Institute and State University
Research Scientist I, EES

Pradeep K. Agrawal, Ph.D.
University of Delaware
*Assistant Professor,
Chemical Engineering*

R. Martin Ahrens, Ph.D.
Washington University
Professor, Physics

James M. Akridge, M.S.
University of Maryland
*P.E.(Georgia)
Senior Research Engineer,
Architecture*

Robert S. Albright, Jr., A.S.
Atlanta Area Technical School
*Research Associate I,
Aerospace Engineering*

Neal T. Alexander, M.S.
Georgia Institute of Technology
*P.E.(Georgia)
Senior Research Engineer, EES*

Cecil O. Alford, Ph.D.
Mississippi State University
Professor, Electrical Engineering

Samuel T. Alford, M.S.
Georgia Institute of Technology
*P.E.(Georgia)
Principal Research Engineer, EES*

Saboz Ali, Ph.D.
Peshwar University
Research Scientist II, Textile Engineering

Douglas C. Allen, M.L.A.
Harvard University
*L.A.(Kentucky)
Assistant Professor, Architecture*

Fred C. Allvine, D.B.A.
Indiana University at Bloomington
Professor, Management

Tom F. Almon, M.A.
Peabody College
Professor Emeritus, English

Fred N. Alyea, Ph.D.
Colorado State University
*Principal Research Scientist,
Geophysical Sciences*

William F. Ames, M.S.
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